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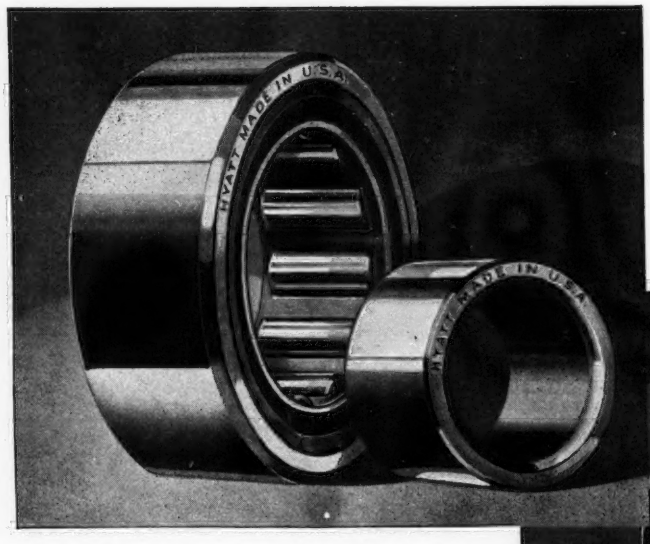

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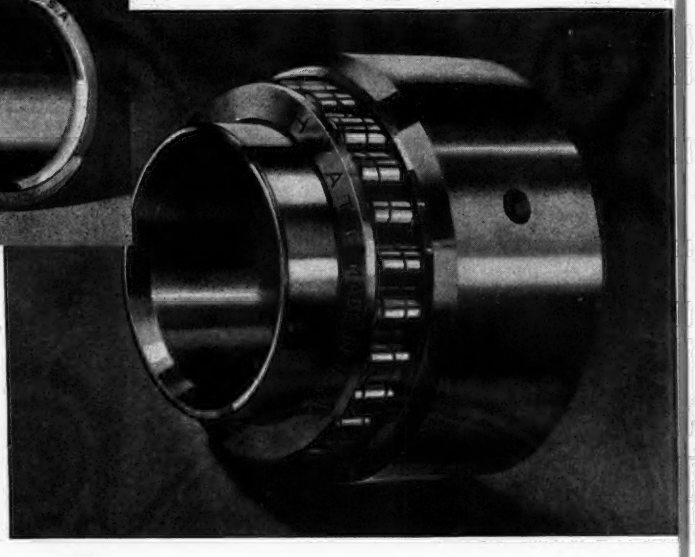

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AGRICULTURAL ENGINEERING

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Cooperation in Agricultural Progress

EXPONENTS of cooperation in work for agricultural progress were numerous and vocal at the winter meeting of the American Society of Agricultural Engineers at Chicago in December. Particular interest was shown in cooperation in research and in extension work; cooperation between public service agencies and industry; cooperation between agricultural engineers and the various agricultural sciences; and cooperation between agricultural engineers working at different points on similar regional problems.

As technically trained men close to the farmer's production and application problems, agricultural engineers should be "naturals" in the field of technical cooperation and efficiency.

Production problems as the farmer knows them, follow no state boundaries. Geographic cooperation is elementary in its logic. Extension follows research as naturally as a plow follows the tractor to which it is hitched. Governmental agricultural service agencies, and the private industries which live by serving agriculture, have technical purposes and problems in common.

Scientific solutions of specific agricultural problems often require engineered equipment and methods for practical farm application. Agricultural engineering interest in controlling physical conditions in farm operations and functions calls for cooperation from the sciences to determine optimum, maximum, minimum, and limiting conditions from the standpoints of the biological processes involved and of market requirements.

One of the greatest problems of science and industry is the integration of results into practical applications. In agriculture we have begun to see that it cannot be left to the farmer to the same extent as it has been in the past. That apparently is one reason why common farm practice has lagged so far behind the advance of agricultural science, and why farmers have not demanded improved materials and equipment in larger volume that they have. No matter how open-minded and progressive the farmer may be, he simply cannot work his farm all day and sit up all night reading about the latest developments in science and industry and trying to integrate them into an improved production program for his farm.

It is up to the developing agencies to integrate and interpret their results into workable methods and equipment which will fit easily into a farmer's operations schedule. Anything that involves too much trouble or disturbance all at once will be put off by most farmers. Improvement in farm practices takes place by evolution, not revolution.

Interest in cooperation indicates growing interest in larger, more basic and complicated problems, and growing confidence that they can be solved by the right combinations of brainpower and techniques. The separate agencies working for real farm improvement can no more progress on a doctrine of technical self-sufficiency, than farmers can progress on the subsistence plan of economic self-sufficiency.

A New Year's Vision

IN OBSERVING the old New Year's custom of reorienting ourselves in the dimensions of time, we dust off the mystic crystal of analysis, and throwing ourselves into an editorial trance, peer into fate's dark storeroom for another glimpse of what lies ahead in agricultural engineering.

And there we see all farm plants and animals marked "For agricultural engineering attention." Corn, wheat, cotton, dairy cows, chickens, and a few other common ones are marked "For MORE agricultural engineering attention." There are some new ones we recognize with difficulty, including tung trees, perilla, pyrethrum, and others.

In addition to this product group we see a negative or pest group, including microscopic organisms, insects and weeds, likewise marked for agricultural engineering consideration.

Before our eyes pass the etherial, intangible forms of "farm living conditions," "farm working conditions," and "farm occupational hazards," also routed for the agricultural engineering work bench.

Each product item bears a long check list of reminders to agricultural engineers, indicating the nature and importance of its products and by-products. This is to be checked by agricultural engineering specialists in power and machinery, farm structures, rural electrification, and soil and water conservation; as to essential production factors, conditions, and operations, from preparatory tillage to shipment to market. The status of development in each condition, control, and operation requirement is to be noted, with the type of agricultural engineering function needed, from fundamental research to extension and farm application. An abundance of "next steps" is indicated.

So much for the objectives and primary work schedule ahead of agricultural engineers. What have they to work with? Now for a look at their professional tool and stock room. One section contains old and new equipment and materials for research. Another is filled with new and used materials and equipment ready to be put to work on farms. A spacious empty corner is "Reserved for agricultural engineering materials and equipment yet to be developed." Alongside is a small shop where some development work is in progress.

In the receiving department assorted packages are being unloaded. They are marked "Technical agricultural engineering problems of the agricultural sciences." One is a piece of special research equipment needing improvement; another, a scientific method of controlling an insect pest, which needs engineered application equipment; others are similar specific problems too numerous to mention.

And right in the foreground sits old Father Time himself, at a desk, with his long beard falling into a large tray of unfilled work orders, behind a sign reading "Trained Agricultural Engineers Wanted."

The image in the crystal grows dim, but we have seen wherein agricultural engineers may enjoy a busy, happy, and prosperous New Year.

Up-To-Date Bibliographies

SUCH IS the gospel of the printed word that not only farmers, but engineers too, have been found basing important and expensive work on published agricultural engineering data which has been outdated and superceded by later and more accurate information. In some cases the older recommendations are not only in error, but are entirely wrong and directly contrary to good practice in the light of present knowledge.

Lewis A. Jones, of the USDA Bureau of Agricultural Engineering, brought up this point in a session of the Soil and Water Conservation Division during the recent winter meeting of the American Society of Agricultural Engineers. He suggested that the bibliography problem is not to produce bigger and more inclusive bibliographies, but up-to-date bibliographies from which sources of misinformation are omitted. This applies to all branches of agricultural engineering as well as to the subject which was under consideration at the time.

New knowledge inevitably supercedes and limits or destroys the usefulness of some previous literature. Technical literature is not written to stand irrevocably for all time. It is written to serve a purpose until something which serves that purpose better is provided. When it becomes obsolete, it should go the way of yesterday's newspaper.

The professional responsibility of agricultural engineers to create a literature of agricultural engineering implies a responsibility to keep that literature up to date, and to weed out and warn information-seekers as to the limitations of articles on various phases of agricultural engineering containing anything which is misinformation, or anything but the best information in the light of present knowledge.

This could be accomplished by frequent review of the various subject matter branches of agricultural engineering by the living authors and committees of other subject matter specialists.

To function efficiently in research, teaching, extension, design, development, engineering management, or any other field of application of agricultural engineering knowledge, agricultural engineers need up-to-date reference material in their field. The American Society of Agricultural Engineers would seem to be the logical body to follow Mr. Jones' suggestion and provide the necessary and qualified committees under its technical divisions, to pass on the technical obsolescence of agricultural engineering literature. They might provide not only bibliographies of up-to-date, thoroughly reliable literature and old literature which still has merit, but also bibliographies of the literature, old or new, which is to be taken with a dash of salt or not at all.

The Final Push in Farm Housing Improvement

A THOROUGH verbal overhauling of the farm housing situation was a feature of one Farm Structures Division session of the ASAE winter meeting at Chicago in December. It all started when the two ladies on the program, Miss Ellen Pennell, associate editor of "The Country Home," and Miss Ruby M. Loper, assistant state agricultural extension agent, University of Nebraska, presented information on what farm women really want in their homes.

Not that the farm women want the impossible, or anything so new or drastically different that years of research and development stand between it and realization. They are asking how they can get things they have seen, or heard about; things already worked out and proven practical. They want the work areas of their homes to be areas where they can work efficiently, and the living areas adapted to the daily needs of the family, with no closed parlor reserved for weddings and funerals.

Nor are these idle dreams. They are backed by a growing purchasing power; a growing realization of their genuine importance to the health and happiness of every member of the farm family; and the cumulative forces of depreciation pushing old farm homes to the point where the only choice is to repair, remodel, or evacuate to new and better farm homes.

The problem of farm women is actually to get the things they want, and that their money will buy, when they spend it. There is the proverbial ethiopian in the lumber pile.

They are not equipped by training to talk to the rural builder confidently, in his own language, as to the construction features which will give them the results they want. And the rural builder, adept at knocking together substantial farm houses from vague plans and old standard construction practices, usually is not equally good at interpreting the wishes of the farm woman as to what she wants, into specific construction details that will give her the desired results. More often he is downright antagonistic to anything that smacks of a farm woman trying to tell him anything about how to do his job.

No hope is seen in the direction of the professional architects. Relatively few of them are qualified to design farm houses, and those few have not found it profitable.

But the situation is far from hopeless. The general design job, by housing, construction, and materials specialists, has followed research and commercial development satisfactorily. As indicated, the extension job of showing farm women what is available in the line of farm home improvements, has made good progress. And a start has been made toward helping building materials retailers and rural builders to meet the new standards in farm housing requirements. This last is the extension job which needs to be followed up to a much greater extent if the desired farm home improvement is to be actually realized, rapidly and on a large scale.

The farm building plan services, extension bulletins, 4H club building projects, builders' schools, builders' and dealers' publications, and extension work of the building materials interests have made the start and can carry it on. They deserve every possible help and encouragement. When they have been enabled to reach every rural builder and building supply dealer with the story of what farm women want in their homes, and how these things can be provided for them, a definite surge of farm housing improvement may be expected.

This is the final push needed to start countrywide action in the construction phase of farm housing improvement, and definitely relegate the jerry-built farm house to the past which it served in the absence of anything better.

Terrace Cross Sections as Influenced by Soil, Crops, Land Slopes, and Farm Machinery

By A. T. Holman

TERRACE cross sections have a way of varying in size, shape, and appearance, and in name. There must be reasons for the extreme variations. If the perfect terrace has been developed, I have not heard of it by unanimous acclamation. It is not the purpose of this paper to describe a new terrace, nor to provide a new name for the broad-base terrace, but to outline some of the factors that seem important in terrace design, and point out some inevitable variations of terraces in size, shape, and capacity.

The keystone of terracing is the cross section, including both the channel and the embankment. The development of the cross section is the last chance to complete an excellent, well-located, and carefully designed terrace; the last chance to counteract, in part, for errors in spacing and grade; the last chance to provide adequate capacity and stability with a minimum cost. Unless otherwise stated, this paper will deal with the broad-base, graded terrace for use on cultivated slopes up to 20 per cent. However, this does not imply that all slopes of 20 per cent should be terraced and cultivated.

The shape of this terrace varies somewhat from the original mangum terrace and from many styles of broad-base terraces. The developed terrace represents a uniform slope from the crest of a terrace ridge to the bottom of the channel of the next lower terrace. The channel is broad and U-shaped on the lower side, and the ridge is rounded on the upper side. This design permits a minimum steepness of slope between terraces, eliminates the objectionable steep slopes on the lower side of the ridge and on the upper side of the channel, provides maximum channel capacity, minimizes poor channel drainage, increases the stability of the terrace embankment, minimizes the difficulty of machinery operation, removes the objectionable dead-furrow from the center of the terrace land, eliminates the necessity of turning on plowed land when plowing point rows, and provides for the automatic maintenance of the terrace.

The influence of soil variations on the design of terraces, at the present time, is based upon opinion rather than fact. Some engineers and soil scientists consider that terrace design should be varied for different soils; others maintain that soil type is not an important factor in terrace design. No doubt this problem will continue for some time to challenge the experimenter, to provoke argument and to perplex engineers and farmers.

Impervious soils absorb water slowly, thus necessitating provision in terrace design for a high ratio of runoff to rainfall. But terraces constructed of these tenacious soils are very strong and durable in withstanding damage from flowing water and the operation of machinery.

Pervious soils, including fine sands and sandy loams, absorb water quickly, thus reducing the rate and quantity of runoff. However, this runoff which may be considerably smaller in amount and lower in rate than that from impervious soils, may damage the terraces to a greater extent than the damage experienced on heavy soils. Terraces constructed of fine sands and light, sandy loam soils are less durable than those constructed of the heavier soils, and should be provided with a larger factor of safety and larger initial freeboard for a given flow, for protection against silting in the channels and shrinkage of the ridges caused by machinery and flowing water.

The most difficult soil combination for terracing is a shallow sandy or silt clay loam surface soil over rock, hardpan, or impervious clay. Associated with this soil combination are low absorptive capacity, large percentage of runoff to rainfall, high rates of runoff, appreciable soil movement between terraces, constriction of terrace channel, and a weak terrace susceptible to damage from both flowing water and the operation of tillage tools. Under these circumstances, conservative spacing, conservative length, and ample cross-sectional area are essential for the successful operation of the terraces.

The most ideal soil combination for terracing is a deep loam, silt loam, or sandy clay loam surface soil over a deep pervious subsoil. This soil condition results in small runoff, low rates of runoff, a minimum of soil movement, minimum channel deposits, and a durable terrace that will withstand flowing water and the operation of machinery with minimum damage. Unfortunately, this ideal combination is seldom encountered, and usually it is not considered necessary to terrace these soils until, through neglect, erosion so damages them that their favorable features are destroyed.

The effect of different soils on terracing cannot be considered alone. Whenever the

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Presented before the Soil and Water Conservation Division at the winter meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 1936.

Author: Agricultural engineer, USDA Bureau of Agricultural Engineering. Assoc. Mem. ASAE.

rate of rainfall exceeds the rate of infiltration, the surplus water must be stored or diverted. Obviously, a great shock to the terrace is experienced when a rain of high intensity falls on saturated soil. Another difficult situation exists when heavy rainfall occurs simultaneously with the melting of snow and the thawing of the ground. This condition may tax to capacity the best terraces. Three practical precautions involve (1) a good grade in the terrace channel to prevent ponds of ice which otherwise would retard the flow of runoff, (2) the construction and maintenance of adequate channel area, and (3) the limiting of drainage area and soil movement by using terraces of moderate length and conservative spacing.

CROP CYCLES AND SOIL EROSION

Well-established crops exert tremendous influence upon runoff and erosion. But the effect of vegetation is in itself confusing and contradictory unless the studies are complete for the full cycle of crop growth and the full range of the season. One must consider the effectiveness of the crop during both optimum and adverse seasons, and during different stages of growth to determine its influence on runoff and erosion.

Dense cover crops unquestionably retard the rate of runoff and erosion when the soil is absorptive and when the rainfall is not sufficient to saturate the soil. But vegetation loses its effectiveness when the crop is dormant in the spring; when the new crop is being planted; when the crop is young and has but slight development of root and stalk; when the plants are seriously injured by frost, drought, insects, and disease; when the plant growth is arrested by harvest or maturity, and when the ground is frozen or saturated.

Carefully planned experiments at the soil erosion stations have been yielding data that show how runoff and erosion are influenced by different crops, crop rotations, and different stages of crop growth. Comparative measurements at the Bethany station over a three-year period show the following average annual soil losses: Corn, 5.31 tons per acre; soybeans followed by wheat, 6.63; wheat followed by clover and timothy, 2.32; clover and timothy meadow, 1.44. These measurements were obtained from corn, soybeans, wheat, and clover on four adjacent terraces of the same design.

Maximum rates of runoff from terraces with different crops follow: Oats, 3.5 in per hr; alfalfa, 3.3; clover and timothy meadow, 2.9; wheat, 2.9; fall plowed cornstalk for soybeans, 3.2; and fall plowed sod for corn, 2.5. These runoff rates were obtained April 3, 1934, when the ground was loose and moist and the plants had just started their spring growth. The results indicate that the crop has a negligible influence on the rate of runoff when the plants are small in the early spring. The seasonal influence of different crops on the rate of runoff is shown in Table 1.

TABLE. 1. RATES OF RAINFALL AND RATES OF RUNOFF FROM TERRACES WITH DIFFERENT CROPS

Date of rain	Average rate of rainfall for periods indicated, in per hr			Maximum rate of runoff from different crops, in per hr					
	5 min	10 min	15 min	Corn	Wheat	Oats	Clover and Timothy	Soy-beans	Alfalfa
6/2/32	3.12	2.76	2.72	1.95	1.60	0.35	1.80	2.60	*
7/4/32	5.04	4.44	3.60	1.95	1.33	0.37	0.56	0.54	*
7/23/32	4.32	3.60	3.28	1.22	1.02	0.44	0.14	0	*
5/21/33	3.12	2.22	1.60	0.91	0.23	*	0.07	0.92	1.52
8/9/33	4.80	3.00	2.88	1.95	1.78	*	0.46	0.59	1.79
8/21/33	2.40	2.40	2.40	1.49	1.10	*	0.40	0.52	1.12
9/26/33	3.60	2.40	2.16	.99	1.95	*	0.94	**	1.22
4/3/34	5.40	4.20	3.40	2.5	2.9	3.5	2.9	3.2	3.30

* No measurement

**Soybeans harvested and land seeded to wheat

An analysis of the runoff data shows that the highest rates of runoff occurred on April 4, 1934. Oats had the highest rate of runoff; alfalfa was second high; fallow soybean land was third; wheat and meadow tied for fourth; while corn land was fifth and lowest.

High rates of runoff occur whenever the crops are in their critical period. The critical period is that period from the time the ground is plowed, through planting, until the crop is well established or laid by. All crops have critical periods during the winter and early spring when they are dormant and then they are injured from frosts, freezes, droughts, excessive rain, insects and disease. Other critical periods for specific crops are: Oats, March and April; soybeans, May and June; corn, May to August; wheat, August to October.

Critical and effective periods of crop growth are well shown by soybeans in 1932. On June 2, the rate of runoff from soybeans, 2.60 in per hr, was 34 per cent higher than that from corn. Four weeks later, July 4, when the soybeans were well established, the rate of runoff from them was only 27.7 per cent as high as the runoff from corn. The rate of runoff from corn was the same for the two rains, 1.95 in per hr. A third rain, three weeks later, on July 23, caused a maximum rate of runoff of 1.22 in per hr for corn, and no runoff from soybeans. Thus, in seven weeks from June 2 to July 23, the rate of runoff from soybeans dropped from the highest to the lowest position in comparison to corn, clover and timothy meadow, wheat, and sweet clover.

High rates of runoff usually cause large erosion losses. The rain of June 2 and 3, 1932, caused an erosion loss of 6.83 tons per acre from corn, representing 83 per cent of the loss for the year. From the same rain, the soybean terrace lost 4.09 tons per acre, representing 98 per cent of the year's loss. The soil loss of 6.83 tons per acre from wheat September 26, 1933, represents nearly 70 per cent of the total loss for the year and 157 per cent of the loss from corn during the 12-month period. In 1934 the rain of April 3 caused 37 per cent of the year's erosion from alfalfa, 90 per cent of the annual soil loss from oats, 33 per cent of the loss from corn and 34 per cent of the loss from soybeans.

INFLUENCE OF CROPS ON TERRACING PRACTICE

The development of terraces has been largely in conjunction with the production of clean cultivated crops, including cotton, corn, and tobacco. Expansion of terracing in grain and forage areas has provoked a temptation on the part of some erosion control workers to disregard established terracing practice and deviate materially from conventional terrace design on the assumption that the addition of a rotation, the inclusion of a legume or small grain crop, or the superimposing of strip cropping on terraces would so reduce runoff and erosion to justify a large increase in terrace spacing, or a reduction of the height and cross-sectional area, or a change of the grade, or a combination of these dangerous practices.

Under favorable circumstances dense-growing crops materially influence runoff. It may be stated that clean cultivated crops experience moderately high runoff more frequently than do dense-growing cover crops. But, studies of the effect of different crops on terrace land indicate that the design of terracing systems should not be altered for different crops, because all crops have critical periods—periods when the crop has negligible influence on the retardation of runoff. The same cross section of terrace, including the stability of the ridge and the channel area, required for corn and cotton, is necessary for wheat, oats, alfalfa, and soybeans.

The degree of slope is dominant among the natural factors that influence the size and shape of terrace cross sections. Terraces become narrower as the slopes become steeper, and it is more difficult to establish and maintain adequate height of the terrace on steep slopes.

The spacing between terraces is an important factor of design that may cause extreme difficulty in establishing a satisfactory cross section. If the terraces are too widely spaced, the drainage area becomes excessive and causes the terraces to become too high for machinery operation if built to the height necessary to provide adequate capacity. If the terraces are too closely spaced, they must be made narrow and peaked as a result of the increase of landslope between terraces. This, again, increases the difficulty of operating machinery.

CHANNEL SIZE EXPERIENCE AND CAPACITY REQUIREMENTS

The dimension and channel capacities of terraces that have proven most advantageous from the standpoint of construction, maintenance, effective control of runoff and facility in the operation of machinery are given in Table 2.

TABLE 2. DIMENSIONS AND CAPACITY OF SETTLED TERRACES, BETHANY, MO., EXPERIMENT STATION, NOV. 1934

Slope of land, per cent	Top width of channel, ft	Base width of ridge, ft	Height of terrace, ft	Cross-sectional area of channel, sq ft	Capacity of channel, in runoff
5	18	16	1.1	13.0	2.5
5	17	15	1.1	11.0	2.5
7-8	16	14	1.3	10.0	2.3
7-8	18	13	1.3	14.2	2.2
7-8	17	15	1.1	10.5	2.1
7-8	17	13	1.1	11.2	2.0
10	14	13	1.2	8.8	2.3
10	14	13	1.1	8.2	2.3
13	13	12	1.2	8.5	2.0

The top width of terrace channels decreases from about 18 ft on a 5 per cent slope to about 13 ft on a 13 per cent slope. The base width of the terrace ridge decreases from about 16 ft on a 5 per cent slope to 12 ft on a 13 per cent slope. The net height of the terrace averaged about 1.2 ft for terraces on slopes of 5 to 13 per cent. The cross-sectional area of the channel decreased irregularly from about 13 sq ft on the 5 per cent slope to 8.5 on a 13 per cent slope. The channel capacity, in terms of inches over the terrace interval, varied slightly as it decreased from 2.5 to 2.0 for slopes of 5 to 13 per cent, respectively.

After allowing a freeboard of 0.25 ft, the net effective terrace height is slightly less than 1.0 ft, and the safe channel storage capacity is about 1.5 in runoff for the drainage area between terraces. Terraces of these dimensions handled successfully flows of 5.1 and 6.1 sec-ft, and 3.5 in per hour. In these recorded runoff periods the terraces with conventional spacing and variable grades of 1 to 4 and 1 to 5 in were not tested to capacity. But these terraces are probably not too large to provide necessary reserve capacity for the larger flows that may be expected.

Exceedingly wide spacing of terraces is decidedly objectionable because wide spacing increases the drainage area, thus reducing the channel capacity in terms of inches runoff; wide spacing is conducive to the extensive movement of soil between terraces, which results in excessive sediment deposits in the channel and the increase in size and number of silt deltas which greatly restrict the normal flow of runoff. Thus the wide spacing causes increased runoff per terrace and contributes to the reduction of the terrace capacity. This condition was observed and measured on both steep and moderate slopes.

Level terraces and those with uniform grades of two per cent or less become dangerous when high rates of rainfall occur. The chief difficulty experienced with level terraces is the formation of silt deltas in the channel. A grade of 3 in in 100 ft permits sufficient movement of water to minimize the formation of silt deposits as channel restriction.

Terraces of one-fourth and one-half size have proven entirely unsatisfactory even with excessive grades of 8 in in 100 ft and permanent meadow cover. Terraces of this type whose original dimensions were 8 ft in width, 8 in in height; and which had a uniform grade of 8 in in 100 ft, lost their effectiveness almost completely in a period of three years during which their average height decreased to less than 4 in, and their cross-sectional area decreased to less than 1.3 sq ft.

Terrace cross sections are influenced by both the machinery used in construction and that used in farming terraced land. The size and shape of terrace cross sections will vary with the type of equipment and the method used in construction. Obviously, it is slow and laborious to construct terraces 25 to 30 ft wide and 2 ft high with small turn plows and old-fashioned A-frame drags. Yet countless good, serviceable terraces have been constructed in this manner. In the final analysis the difference between well-constructed and poorly constructed terraces is the will to have a good terrace. This was demonstrated by Mr. Mangum, who constructed his first terrace by hauling up the terrace with cotton hands and chopping hoes.

CHARACTERISTICS OF THE IDEAL TERRACED FIELD

Good large terraces can be completed immediately with large power units and graders or terracers. But more than good terraces are required to have a good terraced field. The completed terrace is merely a start. The ideal terrace field implies that the terraces have good grades and good spacing. The slope profile is a uniform grade from the top of one ridge to the bottom of the next lower channel. The channel represents the bottom of a broad U, symmetrical on the lower side and joining at its tangent with the convex crown of the ridge. The arc segments of the concave channel and the convex ridge should have equal radii. The average slope on the upper side of the terrace ranges from 10 to 15 per cent.

A terraced field of this type has no furrow on the downhill slope of the terrace, no deadfurrow between terraces, and no steep terrace or channel slopes. The crest of the terrace ridge is rounded, instead of sharp or flat, to permit machinery to roll over the terraces with minimum difficulty. The bottom of the channel is rounded to permit the terrace to drain well by concentrating small flows at the center of the channel, and to permit machinery to operate without difficulty.

Construction of the terrace should be accomplished in the most economical manner that will result in a strong terrace. There should not be sufficient grading on the lower side to develop a channel. About 40 per cent of the grading is accomplished on the lower side of the slope up to 5 per cent, 25 per cent on the lower side of 5-10 per cent slopes, and about 10 per cent on slopes in excess of 10 per cent. The grade of the terrace channel and the ridge is completed with the grader without requiring slip work.

The terrace is maintained by plowing—backfurrowing to the ridge. The land between the upper terrace ridge and the next lower channel is plowed with a two-way

plow, turning all furrows uphill and placing the deadfurrow in the terrace channel. If a wider channel is desired, the deadfurrow is placed along the upper edge of the channel; if a deeper channel is wanted, the deadfurrow is placed in the bottom of the terrace channel. On slopes of 5 to 15 per cent, all farm operations with the exception of seedbed preparation and use of grain binders are parallel to the terrace. No difficulty is encountered in harvesting grain over slopes ranging up to 20 per cent.

Reference has been made to conventional terrace design. Conventional implies neither radical departure from proven practice nor absolute adherence to identical design for all conditions. It is assumed that the terrace specifications in Table 3 are conventional for the humid sections of the central and eastern states. A decrease of 10 to 20 per cent in the terrace interval would make the spacings reasonable for the southern states where there is greater frequency of rains of high intensity.

TABLE 3. VERTICAL SPACING FOR DIFFERENT SLOPES

Slope of land, ft per 100	Vertical interval*, ft
3	3
5	4
7.5	5
10	6
15	8
20	10

*It is anticipated that these spacings will be subject to increase or decrease of about 10 per cent to meet unusual field conditions.

Level terraces are unsatisfactory in most humid sections, although they may have a place in semihumid sections for moisture conservation. Uniform grades of 2, 3, and 4 in per 100 ft are satisfactory, but a variable grade of 1-2-3-4 in per 100 ft is preferable for long terraces. These variably-graded terraces are effective in minimizing damage from intense storms, and in conserving moisture from showers.

Terrace lengths of 900 to 1200 ft are preferable to either shorter or longer terraces. Shorter terraces increase the cost of construction, the cost of farm operations, the cost of outlets, and frequently drain less satisfactorily than terraces of moderate length. Long terraces require extra capacity and increase the hazard from intense storms; 1600 ft is a reasonable maximum limit of length.

The minimum net height of new terraces should be 18 to 20 in. The height of compacted terraces should be 16 to 18 in. For corn or other clean, cultivated crop a minimum net height of 16 to 18 in will be reduced about 3 in by cultivation to a net height of 13 to 15 in at the end of the growing season. A net height of 13 in is considered the minimum safe height for terraces in undisturbed condition. The combined width of terrace ridge and channel represents about 30 ft on 5 per cent slopes, 25 on 10 per cent slopes, and 20 on 15 per cent slopes.

The use of terraces offers opportunity for constructive service in soil conservation. Terraces are not needed where the nature of the soil, the crops, and the climate form a favorable combination to prevent erosion; these lands should not be penalized by forcing them to carry the unnecessary burden of terrace costs. But where the soil, the crop, and the climate combination causes erosion or does not arrest it, terraces should be used. And the best terrace that can be designed and economically constructed should be built.

There is no justification for poor terraces, weak terraces, miniature terraces, and mythical terraces; only the best terraces can be justified. It is of course economic mismanagement to permit countless acres of good land to wash away for the want of terracing, while effort and resources are employed ineffectually in the reclamation of submarginal lands, unless it is necessary to reclaim the latter to protect the good land.

EFFECTIVENESS AND LIMITATIONS OF TERRACES

Good terraces are effective in controlling runoff and erosion from grass, grain, and legume lands, as well as from land in clean cultivated crops. Comparative measurements from the Bethany station show the following soil losses. In 1933, the terraced corn field lost 3.78 tons per acres, while the unterraced field lost 27.09 tons per acre; terracing decreased the loss by 86.1 per cent. Over a two-year period the terraced alfalfa area lost 2.72 tons per acre, against 17.15 tons per acre from the unterraced area; terracing reduced erosion by about 84 per cent. In measurements of a four-year crop rotation on terraced and unterraced strip areas, the loss from terraces was 6.77 tons per acre, and 30.01 from the contour strips; terraces here reduced erosion by 77.2 per cent. In the last six months of 1934, a terraced wheat field lost 4.56 tons per acre, while the adjacent unterraced field lost 24.74 tons per acre; terraces reduced the soil loss by 21.8 tons per acre, or 82.3 per cent.

SUMMARY AND CONCLUSIONS

(1) Although difference in soil type, eventually, may influence the design, construction, and operation of terraces, present information does not justify radical departure from conventional terrace design and specification.

(2) The rate and quantity of runoff from terraced land vary materially for different crops. But equally large variations in runoff and erosion occur for the same crop in the different stages of its growth, and for different seasons and climatic conditions. Present data indicate that it is an unsound practice to lower the standard of terraces on the assumption that cover crops, including legumes and small grains, and rotations and strip cropping will greatly reduce runoff and erosion from the most damaging rains.

(3) The degree of land slope continues to be the dominant factor in determining the spacing of terraces and in limiting the width of terraces. Present data and experience indicate that conservative spacing of terraces should be continued.

(4) Terrace construction should be accomplished in a manner that prevents the development of a furrow at the base of the terrace on the lower side. Tillage and maintenance practice should be so accomplished that a uniform slope of soil will develop from the crown of a terrace to the bottom of the channel of the next lower terrace.

(5) A net terrace height of 13 in has conveyed flows of 6.1 sec ft, but the cross section and channel were large. New terraces should have a minimum height of 18 in, if the spacing, length, and grade are normal.

(6) Well constructed terraces have not interfered with the operation of machinery. But, farm machinery could be operated more advantageously, if greater flexibility were provided.

(7) Terraces should be used to prevent erosion on good farm lands before they erode to the marginal or submarginal state.

(8) Good terraces have been effective in preventing 80 to 85 percent of the erosion occurring for different crops. The conservative design of terrace cross sections requires ample channel area to prevent overtopping, and adequate size and stability of the ridge to prevent breaking.

A Study of the Southern Farm Home in Relation to Comfort

By J. W. Simons and Frank B. Lanham

COOLING our bodily environment in summer is a vitally important part of the work of providing ourselves with ideal living conditions. Despite the rather widespread introduction of air cooling and air conditioning, proper emphasis is seldom placed on protection from solar heat. This is a most pertinent problem in the southern sections of the United States.

Under an agreement becoming effective February 1, 1936, a cooperative research program was initiated between the Bureau of Agricultural Engineering, U. S. Department of Agriculture, and the College of Agriculture of the University of Georgia. This paper is a progress report of the research project entitled, "An Investigation of Farm Houses." The purpose of the study being conducted at the university is to develop more satisfactory types of low-cost construction for farm houses.

The immediate objectives of the investigation are to determine temperature, humidity, air motion, and lighting conditions in farm houses; to evaluate the absorption of solar radiation and atmospheric heat by farm buildings; and to devise inexpensive structural means, including the utilization of agricultural by-products and wastes, for maintaining satisfactory temperatures, humidity, and air-motion conditions in farm houses and farm buildings.

Surveys of farm housing conditions, notable among which was the Federal Farm Housing Survey, revealed the seriousness of the rural housing problem in the southern states. The federal government, cooperating with the individual states, early realized the importance of improving farm living conditions and has, through resettlement projects, financing agencies, educational programs, bulletins, and other means, attempted to cope with the situation. Early efforts in this regard have proved fruitful, although similar to all widespread improvement programs progress has been slow and painstaking.

In improving the living conditions of rural people in the southern states, the several active agencies have been forced to advocate houses of the conventional low-cost type. Factors relating to comfort were doubtless considered in some cases but were eliminated chiefly because of cost. Manifestly but little knowledge is available concerning the more simple factors which relate to comfortable living conditions and protection from heat, so important in the South. Definitely, then, the possibility exists that through simple design characteristics, in conjunction with the application of some of the more fundamental scientific principles, comfort may be promoted in the most moderately-priced southern farm home.

In reviewing the "Experiment Station Record" and "Engineering Index," outlines have been found of numerous projects pertaining to the various phases of air conditioning. Commercial concerns also have constructed model houses and have attempted to investigate, in a limited manner, their ability to supply comfort. However, the behavior under actual conditions of building materials suitable for low-cost construction of the southern farm home, has not been extensively studied. Neither has the relation between the factors of temperature, humidity, and air motion been solved in a manner satisfactory to the southern farm builder.

While thought along the line of needed research was being crystallized into the development of this particular project, it was believed that sufficient data could be obtained through studies of occupied farm houses. However, because occupied houses can not be altered as desired, it was deemed necessary to build an experimental house which could be readily changed in many ways. Several occupied farm houses are under study as a means of comparison, but the major part of the research work will be carried on in the experimental house.

The experimental house is a small, three-room structure, 17 ft 4 in by 27 ft 2 in in size and of a design common in the southern states. One of the principal ideas kept in mind while designing the house was that the construction should be similar, as far as possible, to that of the typical farm house.

Exterior and interior finishes are in the form of panels screwed directly to the studding so that other types of finish may be easily substituted. Window and door frames and also headers are fastened with angles and screws so that they may be shifted either vertically or horizontally to any position along the wall.

An elevating arrangement provides means for raising the entire roof structure so that stud walls, which are bolted to sills and roof structure, may be removed and walls of another height inserted.

An inexpensive type of construction is being used for the first series of tests on the house. The foundation con-

Presented before the Farm Structures Division at the winter meeting of the American Society of Agricultural Engineers, at Chicago, December 1, 1936.

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THE EXPERIMENTAL HOUSE AT ATHENS, GA., SHOWING BOX ON ROOF PROTECTING PYRHELIOMETER, AND CABLE AND WINDLASS SET-UP FOR STABILIZING ROOF DURING CHANGES IN CEILING HEIGHTS

sists of brick piers; flooring is of plain boards; exterior walls are of weather boarding, and the roof is of solid sheathing covered with 55-lb roll roofing. No ceiling or inside finish was used. As the work progresses, changes will be made to duplicate better types of construction.

It is well known that, in general, air temperatures in occupied rooms are seldom uniform, there being ordinarily a distinct temperature gradient from floor to ceiling, even where no artificial heat is supplied. A level of 3 ft 6 in above the floor has been taken as a standard height for measuring air and wall-surface temperatures in the rooms. This level approximates the height of the breathing line of a person seated.

Temperatures throughout the house are obtained by the use of copper-constantan thermocouples, there being seventy-two in use with the present construction. Measurement of these temperatures is accomplished by means of a sensitive potentiometer. An ice bath is used to maintain the cold junction at 32 F (degrees Fahrenheit).

A series of thermocouples is used on each of the four exposures of each room. Temperatures obtained are of the outside air one inch from the wall, the outside wall surface, the inside wall surface and the inside air one inch from the wall. Whenever an inside finish is applied, two additional thermocouples will be needed for each series to measure the air temperature in the wall construction adjacent to inside and outside finishes. Similar series are used on roof, ceiling, and floor. Thermocouples have been placed also in cornices and gable louvres to measure the temperature of incoming and outgoing air, and in typical framing members to determine any temperature change in the structure itself.

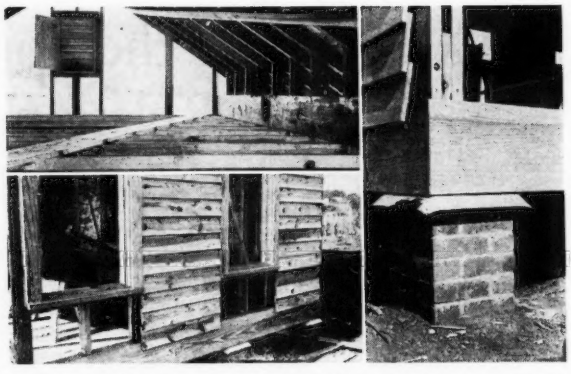
A cross section of the air temperatures at various levels in a room is secured by means of a portable stand on which thermocouples are mounted at the levels desired. Also attached to this stand is a globe thermocouple, which consists of a thin copper globe painted black with a thermocouple mounted in the center. Because of the fact that the black globe absorbs radiated heat, the temperature of the globe, which is measured by the thermocouple, will be the resultant of the heat received by and dissipated from the globe, by both radiation and convection. All other thermocouples which measure air temperatures are protected by cylindrical radiation shields of highly reflective material so that only the air temperatures will be obtained.

As a means of checking thermocouple temperatures, four mercury thermometers are used in each room, mounted one inch from the wall. A hygrothermograph placed in the center of each room gives a continuous record of temperature and relative humidity.

Outside temperatures are obtained by means of a mercury thermometer and a recording gas bulb thermometer. Later it is planned to build a U. S. Weather Bureau type of instrument shelter in which will be installed a recording psychrometer.

Air motion in the house is measured by the use of vane anemometers and Hukill thermocouple anemometers. The former type will be used mainly for measuring air movement through doors, windows, and louvres. The latter type is used for measuring very low velocities, below the range of accuracy of the vane type. Thermocouple anemometers have been mounted in cornices, louvres, and under the floor. One mounted for portable use can be placed on a stand at any desired level, or held at any location on the floor, walls, or ceiling.

Outside wind velocity is measured by a U. S. Weather Bureau type of whirling cup anemometer, while wind direction is indicated by a weather vane with a dial graduated in 15-deg intervals.



(UPPER LEFT) VIEW OF RIGID ROOF CONSTRUCTION, DESIGNED TO WITHSTAND ELEVATING FOR EXPERIMENTAL PURPOSES. (LOWER LEFT) ILLUSTRATION OF PANEL CONSTRUCTION. (RIGHT) CORNER DETAIL, SHOWING BRICK PIER AND TERMITE SHIELD

Solar radiation is determined by a pyrheliometer of the type used by the Weather Bureau. This instrument consists of a thermopile, alternate junctions of which are attached to but electrically insulated from two concentric silver rings. One of the rings is painted white, the other black. This receiving element is hermetically sealed in a 3-in diameter glass bulb. Because of the difference in color, the rings absorb radiant heat unequally, the black ring being heated more than the white one. The resulting temperature difference varies with the rate at which radiant heat is received upon the two rings. The magnitude of the electromotive force developed by the thermopile, therefore, is a measure of the intensity of solar radiation. A single-point, curve-drawing potentiometer recorder automatically measures and records the millivolt values.

While practically all factors which are now known to affect comfort can be measured by the methods just described, it is sometimes difficult to interpret these data in terms of bodily comfort. To assist in doing this the use of a thermo-integrator or eupatheoscope is being considered. This consists of a hollow black copper cylinder with hemispherical ends. Current passed through a heating coil in the center of the cylinder is so adjusted that the energy dissipated per square foot of surface is approximately equal to the rate of heat loss of the human body. A thermopile with measuring junctions attached to the outside surface measures the average temperature of that surface. The surface temperature is obviously affected by the three factors of air temperature, air movement, and radiation, but, so far as is known, is virtually unaffected by the fourth factor, relative humidity. While this may not be an exact measure of the comfort or discomfort experienced by the human body, results reported by other investigators indicate that, with it, comfort conditions can be measured much more nearly than is possible by temperature measurements only.

As the project is rather broad in its general scope, it was decided to set up a series of specific problems so that definite and usable results might be obtained. In so far as possible the work of each problem is to be completed before beginning another. The investigation contemplates work on the following problems in the near future:

1 Absorption of solar heat during typical hours of the day.

2 Loss of absorbed heat by radiation during the night period.

(Continued on page 14)

The Engineering Aspects of Farm Operating Efficiency

By Geo. R. Boyd

THE FARM has often been compared with a factory. It is operated for the production of livestock, food, and raw materials for use in industry. The soil, buildings, machinery, and livestock make up the plant to correspond to the buildings, machines, and equipment of a plant for the manufacture of shoes or other articles. Labor of course is involved in the farm factory, in the same way in which it is involved in a shoe factory. The crops to be grown, the selection and sale of the products, do not come within the field of the engineer. On the other hand, the equipment and the labor used are engineering matters and within the province of agricultural engineers.

To be efficiently operated, the farm factory as well as a shoe factory must be so organized, equipped, and coordinated that each one of the separate parts fits into the production program and is coordinated with all of the other parts. No factory can long stay out of bankruptcy which provides more power than is needed, which has one machine with twice the capacity of the next machine in the production line, or which has machinery and equipment not adapted to the kind of products which are to be manufactured. A superficial investigation of any farm will probably discover a number of maladjustments between the various engineering elements of the farm business, or between one or more of these engineering elements and the farm business as a whole. Under any kind of an agricultural production program it is the efficient farmer who will survive, and it seems to be the field of the agricultural engineer not only to design the machines and equipment to be used, but also to coordinate them for the purpose of securing efficiency in farm operation.

In 1929 the Bureau of Agricultural Engineering instituted a research project for determining the engineering needs of typical farms in the various states and the benefits which would result from the adoption of the indicated improvements. Since all suggested improvements would be financed by the landowners, it was necessary that the farms selected be those whose owners were progressive minded, who were financially able to make the recommended improvements, and who were keeping farm accounts, this last requirement being necessary because it is from these farm accounts that the benefits of the improvements, when and as made, will be determined. These limitations confined the cooperating farms to the better class of farms in each community. In fact, each farm is generally recognized as being one of the best in its locality. To date 107 of these farms in Georgia, North Carolina, South Carolina, Virginia, Michigan, Minnesota, and Ohio have been studied, and the scope of the project is being extended as funds become available.

Early in the investigation it developed that an engineering development program depended entirely upon the agricultural program and that it was impossible to plan a long-time engineering program on a farm without, at the same time, planning the cropping system and the livestock production to be carried on during this time. In spite of the fact that all of these farms are among the leaders in their respective communities, it was evident even to an engineer that the agricultural phases of the farm program were far from the best, and it therefore became necessary to call in the assistance of the farm management authorities in each state for the purpose of working out a coordinated program in which each element of the farm business —the crops, livestock, buildings, equipment, soils, and the shape and condition of the fields—were all taken into consideration, each element in the completed plan being in the proper ratio to each other element and to the farm business as a whole.

In developing these farm programs, primary consideration is given to the personal equation of the owner, for of course the crops to be produced must be those he likes to handle and that he knows how to raise. In fact, the farmer himself is probably the most important member of the planning unit, because of his intimate knowledge of the farm and since any plan, to be successful, must be within his capabilities. As might be expected, the 107 farms studied covered a wide variation in size, type of farming, and soil and climatic conditions, as well as in crops produced and equipment used. There was not one of the farms which did not require a number of different engineering adjustments in order to promote efficiency. These adjustments were not expensive, most of them calling for the expenditure of very little capital and a number of them being of the kind that could be done largely with farm labor.

A number of striking maladjustments between various elements of the farm business were brought to light, as, for instance, a farm in southeastern Virginia having about 20 acres in cultivation and relying for its main income on a half dozen cows and a few chickens, had no other power on the place than a tractor. Another farmer had a complete outfit of power machinery, including a three-row, general-purpose tractor outfit and a ten-foot combine on a farm with 260 acres of cultivated land, 60 acres of which were in small grain, and with no field on the farm more than 4½ acres in size. This latter case is a striking example of the lack of coordination between engineering elements of the farm business, since the size of the fields was determined by open lateral drains which cut the fields up into such small units that the economical operation of equipment was impossible. Incidentally, the substitution of tile drains for the open lateral ditches not only eliminated the cost of annually clearing the open ditches, but added 10 per cent to the cultivated area of the farm. The income from this additional 10 per cent of area, with no increase in overhead costs, will be nearly all profit, and at the same time operating costs on the remaining 90 per cent will be markedly reduced. Another example of a different type is a farm, largely in apple orchards, which had been leased

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A combination of two similar papers presented before the North Atlantic Section of the American Society of Agricultural Engineers, at Skytop, Pennsylvania, October 16, 1924, and before the Soil and Water Conservation Division at the winter meeting of the Society at Chicago, December 1936.

Author: Assistant chief, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. ASAE.

out at a nominal rental by the owner on account of the difficulty of securing labor for orchard maintenance. The installation of a stationary spray outfit so reduced the amount of labor required that the owner now operates the orchard himself with a considerable gain in income. In this case, a single engineering improvement changed the entire plan of operation for the better.

While it has been possible on each of these farms to indicate various engineering improvements which, in conjunction with the revised agricultural program, will result in increased net income, the studies so far have brought to light some rather fundamental considerations as to the effect of the various engineering elements of the farm business upon the farm business as a whole. For instance, in the southeastern states, particularly, and in other states to some lesser degree, the farm surveys brought out the fact that many farms have too many fields, irregularly shaped and varying in size. For instance the average number of fields per farm in the 20 farms studied in Georgia was 28.4. One farm had 74 fields which averaged 2½ acres in size. A considerable number of these farms had from 20 to 30 fields averaging 4 to 7 acres per field.

For may years past agricultural authorities have been trying to establish on southeastern farms a systematic, soil-building crop rotation but without success, as evidenced by the fact that not one of these 20 farms, each one being among the best in its locality, was following a balanced rotation system. It is obviously physically impossible with so large a number of fields of varying sizes to carry out any farming program which alternates the crops to be produced between the various fields in such a way as to build up soil fertility, and, at the same time, produce each year approximately equal amounts of various crops. The plans as developed under this project have cut the number of fields down to a minimum, approaching the number of crops in the rotation program. The expense of reducing the number of fields has been small, involving usually the substitution of broad-based terraces for steep, narrow ones, the removal of fences and hedgerows, and, in some cases, the substitution of tile drains for open ditches. This is an example of a comparatively simple engineering improvement which is fundamental to the entire program for improved agriculture and soil conservation in the southeastern states.

It has been somewhat surprising to notice the effect of buildings upon the farming program in the central western states. In this area agricultural authorities have demonstrated that, in general, the most prosperous farms are those having the highest density of livestock per acre. Our investigations have so far confirmed these findings. It is obvious that without adequate farm buildings for the protection of the animals and for storing feed for livestock, the farmer can not develop a livestock enterprise. Without buildings for livestock and feed storage, a farmer must necessarily turn to the production of cash crops which must be sold approximately as soon as harvested. This type of agriculture is not only less remunerative than livestock farming, but it is a hard system as regards the preservation of soil fertility. As a matter of fact, almost all of the farming systems in the central west are built around the buildings rather than around the machinery, power, or specialized crops. Although no detailed studies have been made of farms in the north Atlantic states, it is evident that most of the farms are amply equipped with buildings. It is true that many of them are out of date and not adapted to modern needs, but judging from trends developed by our work in other states, it would seem likely that the most efficient development of New England farms would include a complete use of the farm buildings.

FOR MAXIMUM SUCCESS IN FARMING THE LIMITING CONDITIONS OF THE INDIVIDUAL ENTERPRISE MUST BE DETERMINED AND THE VARIABLE FACTORS ADJUSTED ACCORDINGLY

With reference to power and machinery, it is of course entirely possible to build a farming program around power and machinery. In fact, that is what the farmer without buildings must do. In areas where land is cheap, and particularly in one-crop regions such as the wheat areas of the northwest, farms may be organized to fit the available capacity of the equipment to be used. In a settled community where land is expensive, where adjustments between abutting landowners are not easily made, and where a variety of crops can be produced, it is evident that the machine must be fitted to the farm rather than the farm to the machinery.

The economics of farm machinery from the farmers' standpoint is a complex thing. If a salesman were to attempt to sell a factory owner a piece of equipment which could be used only a week or two a year, he would not get to first base with his prospect, but with farm machinery the length of time of use annually may be immaterial. Unfortunately, the demands for farm labor and equipment are not uniform over the cropping season, but a number of major and minor peaks are usually found over a period of a few months. If an additional piece of equipment helps to ease the peak load, it may be an economical purchase although used only for a limited time. Here, again, the necessity of planning the equipment in connection with the farming program is demonstrated since much may be done in adjusting the kind and quantity of various crops to relieve peak loads. Advertisements in farm papers are often seen to the effect that "John Jones, by using our equipment, raised corn at a cost of 25 cents a bushel", and the inference is that the reader can also raise corn for 25 cents a bushel, provided he purchases the same equipment that John Jones used. This is wrong since the way in which the equipment fits into the entire farming program is the determining factor as to its value. The cost of the equipment is paid out of income from the entire farming operation and not from funds derived from one field or one crop. It has been brought out by our investigations that even though the cost of labor-saving machinery be high for an individual crop, if the labor saved can be used on the farm in caring for additional livestock or in the production of some specialized crop, *(Continued on page 14)*

Determining Flood Discharges from Small Watersheds

By David L. Yarnell

IN THE course of working up flood data in connection with rainfall records, contained in U. S. Department of Agriculture Miscellaneous Bulletin No. 204, entitled "Rainfall Intensity Frequency Data", it was observed that on each watershed studied there was a direct relation between the amount of rainfall and flood discharges. A graphic method of representing this relationship has been devised so that it is apparently possible to predict flood magnitudes and frequencies from fragmentary or short-period data.

The proposed method utilizes as data (1) information on past flood quantities and frequencies, (2) the precipitation charts published in Bulletin 204, and (3) the time of concentration of the flood waters.

To use the method, first prepare by interpolation a set of intensity-frequency curves as shown in Fig. 1, based on the charts in Bulletin 204. The intensities in this graph are plotted as ordinates against duration as abscissas on log log paper. Smooth curves are drawn through the points for each frequency. The vertical dotted line is the time of concentration, in this case 2.1 hr. At the points where this dotted line intersects the various frequency lines, the intensities are read from the scale at the left. These intensities are plotted as ordinates on log log paper with their respective frequencies as abscissas, as in Fig. 2. On log log paper these points will lie on a smooth curve approaching a straight line. On the same graph, using the same frequency scale and with the discharge scale having the same phase length as the intensity scale, plot the available flood discharge-frequency data which should be most reliable for the 2, 5, and 10-yr frequencies. If these data are based on a long continuous record, the curve representing discharges for the various frequencies will be parallel to the curve representing the rainfall intensity-frequency data. Figs. 2 to 4 are such curves prepared for small watersheds in various sections for which the necessary data are almost complete. Table 1 gives further information as to the watersheds and streams shown in the graphs.

Author: Senior drainage engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. ASAE.

TABLE 1. WATERSHEDS FOR WHICH THE CORRELATION OF RAINFALL-FREQUENCY AND FLOOD-FREQUENCY WAS STUDIED

State	Stream	Gaging Station	Area of watershed, sq mi	Total length watershed, mi	Approx. average width, mi*	Total fall, ft	Computed time concentration, hr	Length flood record yr
Mass.	East Branch Tully River	Athol	50	9.8	—	374	2.1	18
Mass.	Middle Branch Westfield River	Goss Heights	53	18.4	2.9	1662	1.8	24
N. C.	Valley River	Tomatla	106	19.1	7.7	1450	2.9	26

*This column is not necessarily equal to area divided by length.

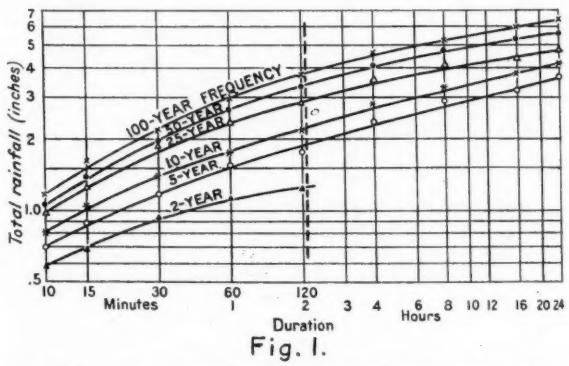

Fig. 1.

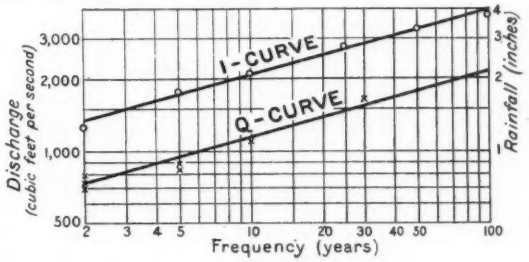

Fig. 2.

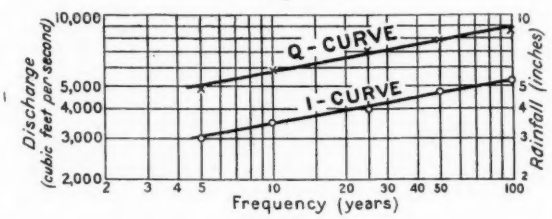

Fig. 3.

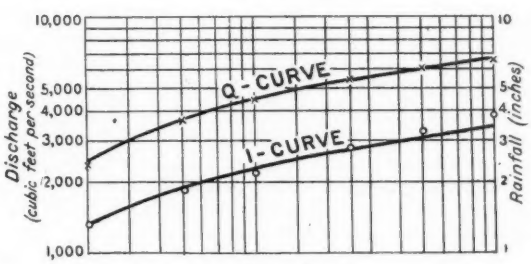

Fig. 4.

FIG. 1 INTENSITY-FREQUENCY CURVES FOR EAST BRANCH, TULLY RIVER, ATHOL, MASS. (50 SQ MI) FIG. 2 DISCHARGE-FREQUENCY CURVES FOR EAST BRANCH, TULLY RIVER, ATHOL, MASS., (50 SQ MI) FIG. 3 DISCHARGE-FREQUENCY CURVES FOR VALLEY RIVER, TOMATLA, N. C. (106 SQ MI) FIG. 4 DISCHARGE-FREQUENCY CURVES FOR MIDDLE BRANCH, WESTFIELD RIVER, GOSS HEIGHTS, MASS. (53 SQ MI) THE "I" CURVES DATA ON INTENSITIES FROM U. S. DEPARTMENT OF AGRICULTURE MISC. PUBLICATION NO. 204. THE "Q" CURVES WERE PLOTTED FIELD DATA.

It is obvious that this method is based upon uniform rainfall over the watershed and its application must be limited to small areas where such uniform rainfall is possible. It is thought that the method will not apply on watersheds of over 200 sq mi.

If the parallelism of the two curves is definitely established, as all researches so far made indicate, it follows that (1) data on the quantity and frequency of one flood will locate the flood discharge-frequency curve so that the size and frequency of all floods over a hundred year period may be estimated and (2) the effect of any improvement which affects the time of concentration can be forecast.

Caution should be used in extending the discharge-frequency curve beyond the one hundred year frequency, although I believe the results so obtained will be as reliable, if not more so, as those obtained by flood runoff formulas.

Acknowledgements:— This investigation was made under the direction of S. H. McCrory, and L. A. Jones. The author desires to express his appreciation for suggestions to C. J. Posey, and E. W. Lane, and to D. G. Miller, John G. Sutton, and C. E. Jacoby of the Bureau of Agricultural Engineering.

A Study of the Southern Farm Home in Relation to Comfort

(Continued from page 10)

3 Effect of ventilation in carrying off absorbed heat.
4 The effect of artificial heat upon comfort.

Several preliminary tests have been made to determine the absorption of solar heat during typical hours, although no conclusions have been drawn from the data obtained. The tests were taken during periods of low wind velocity so that losses by convection and air leakage would be at a minimum. In addition, a clear sky was considered essential because under this condition the solar radiation would be more nearly uniform. The doors, windows, and louvres, which had been open during the morning, were closed after readings of outside wind velocity and temperature had been taken. Temperature readings were taken through a 1-hr period. The heat gain was computed and compared with the solar heat received upon the structure. Because the pyrheliometer measures the intensity of solar radiation on a horizontal plane, the areas of the walls and roof which intercept solar rays must be interpreted in terms of heat received on a horizontal surface. The simplest method for accomplishing this is to measure the area of the shadow cast by the structure on a horizontal plane level with the base of the house. Equipment is being devised by the Bureau by which this area may be quickly computed for any time of day without the necessity of actually measuring the shadow.

In studying the effect of ventilation upon the removal of absorbed heat, window and door locations will be given much consideration. This will entail shifting the windows not only horizontally along the wall but also vertically. Ceiling heights of 8, 9, 10, and 11 ft will be studied.

Ventilation of the attic by natural means will be studied. Investigations will be made of the value of various sizes of conventional louvres, completely louvred gable ends, cornice openings, ridge ventilators, and chimney flues for removing absorbed heat.

In preparation for the ventilation tests, windows, doors, and louvres are being calibrated for average rates of air flow under varying wind velocities and directions. This is necessary in order to obtain correction factors to apply to readings obtained in the center of such openings during the actual ventilation tests.

This progress report presents the general purpose and plan of the investigation. The nature of the problem has given rise to several difficulties in relation to the correct experimental procedure, and much time has been required in formulating the proper method of attack. However, because of the desirability of providing comfortable living conditions for the farmer and his family, the study has been deemed to be so fundamental in nature as to warrant a careful and thorough study.

Engineering Aspects of Farm Operating Efficiency

(Continued from page 12)

the investment in the machinery will be justified by the net returns from the farm business as a whole.

So far we have studied 20 farms in Georgia in five widely different areas of the state. The most prosperous of all these farms during the year in which the surveys were made was a mountain farm, mostly rough, stony, steep land with some bottom land subject to over-flow along the creek, and with a total of 30 acres in cultivation. No one could be criticised for classifying this farm as submarginal, but due to the labor and equipment put on that land by the owner he had a net cash income, aside from the family living produced on the farm, of $3,000 which exceeded the earnings of all of the Georgia farms studied that year, and there are included in the study some large farms well adapted for general agriculture. The farmer and his family have considerable labor and use it in producing vegetables, fruits, and berries, which with the milk and butter produced by six cows, give them a lot of perishable commodities. The farmer has a truck, and because of having this piece of equipment he is able to haul these perishables to market daily. Without it, he would be unable to market his produce to any advantage since he is 15 miles from town.

Another farm, in Virginia, was so hilly and rough and so badly cut up by steep hillsides and rocky streams that it appears that the farmer is working under great disadvantages. Nevertheless this farm has for many generations produced a living for from three to five families every year. We have other examples of prosperous farms which have been developed on poor soils or under conditions of poor natural advantages which are supporting and for years past have supported farm families. This does not mean necessarily that there is no such thing as submarginal land, but our studies tend to show that the fertility of the soil is not the most important factor in determining the profitableness of any farm. So far the results seem to show that it is the labor and equipment, including buildings and machinery, which are put on the land, which determine its income value. These are the engineering elements of the farm business, and it would appear that the importance of their effect upon the farm business has been underestimated in planning for better agriculture and more prosperous farms.

Soil Moisture Conservation

By Raymond R. Drake

THE most effective means of obtaining moisture for the soil is to retain the precipitation where it falls. Many agronomists and engineers recognize this fact, as well as the advantages to be gained by the use of certain cultural methods which keep the soil in a roughened surface condition, receptive to the maximum amount of moisture, and conducive to the control of runoff and erosion. In some sections of the country contour farming has been reasonably successful as a method of conserving moisture, especially when combined with terracing and strip cropping. The comments in this paper will have particular reference to the central great plains area.

Ground that has grown a wheat crop is usually dry at harvest time. Replacement of the soil moisture before seeding time depends upon two factors: (1) the amount of rainfall received, and (2) the portion of water that it is possible to store in the soil. Very little moisture can be stored in the soil during a season of unusually low rainfall accompanied by extremely high temperatures, even though the best methods are used.

When no effort is made to conserve the moisture in a favorable year the entire amount of rainfall is usually lost in runoff, evaporation, and weed growth. The surface condition of the soil with respect to tillage, amount of organic matter, and the intensity of rainfall, will determine the amount of water absorbed by the soil. More water is usually stored in soil receptive to moisture from intense rainfall than in soil in a nonreceptive condition, from a low intensity rain of the same total amount. The total amount of rainfall is a general index to the amount of water stored in the soil, however, it may be modified by the different methods of handling the soil and the intensity and amount of rainfall received.

That portion of rainfall not stored as soil moisture is lost by runoff, evaporation, transpiration and penetration. Tilth and structure of the surface soil and the condition of vegetation have their influence upon the rate of water penetration. When soil conditions are favorable for moisture absorption and the intensity of rain is not excessive, little water is lost. Proper tillage should put the soil in an absorptive condition and at the same time place the soil mechanically in a position to hold large quantities of free water. The holding of free water by surface storage and by increased void space presented by tillage will materially reduce the runoff losses during periods of intense precipitation. Rough and cloddy soils permit the rainwater to penetrate quicker than a fine smooth surface, because of greater air space between the soil particles. Growing vegetation and organic debris mixed throughout the surface soil acts as a sponge in absorbing rainwater, preventing runoff, and giving the soil time to absorb the water.

The surface soil begins to lose water immediately after a rain has stopped. If the land is covered with growing vegetation, the loss of water is by transpiration and evaporation. When clean cultivation is practiced, the loss is only by evaporation from the surface soil. Very little evaporation occurs from the second foot or subsoil, although it does occur during long, hot, dry periods. If weeds are permitted to grow during favorable seasons of precipitation, little or no moisture will be stored in the subsoil for future needs. Loss of water by evaporation is unavoidable and accounts for the highest percentage of water loss. This is especially true when the rain comes in small showers. High temperatures and winds, so characteristic of the plains region, will evaporate most of the water received from small showers. When the rains occur close together, the moisture from the first rain may remain close to the surface, in which case a higher percentage of the second rain can be stored in the subsoil. Water will not penetrate the soil until the per cent of moisture is in excess of its field-carrying capacity, which is a quantity of moisture that a soil must contain before water can pass through to lower depths. The first foot of soil must be wet to its field-carrying capacity before any water can pass through to the second foot. When the first and second foot are both wet to their field-carrying capacity, additional moisture will pass through to the third foot and so on. When soil is filled to its field-carrying capacity, as sometimes occurs in fallow ground in September, runoff is almost sure to occur, due to the slow absorption of water.

Farm lands must be tilled to prevent weed growth, for soil tilth, to prevent crusting, and to keep the soil in a cloddy, open condition receptive to moisture absorption. The wheatland listers, ridge busters, one-way disk plows, subsoil packers, and surface-shovel cultivators will usually be sufficient tillage machinery for most farms for growing wheat and row crops, and for summer fallow tillage. The necessity for storing moisture is illustrated in Table 1.

Wheat planted in dry soil resulted in failure eight times out of thirteen plantings, and a 20-bu per acre crop was never produced. Wheat planted in soil wet 3 ft or deeper resulted in only one failure in 31 plantings. Crops of 20 to 40 bu per acre or more were grown 27 out of 31 times.

The effect of tillage in storing water in the soil is illustrated in Table 2.

In a 22-yr period, the soil was dry 12 times when wheat stubble was late fall plowed, once when early fall plowed,

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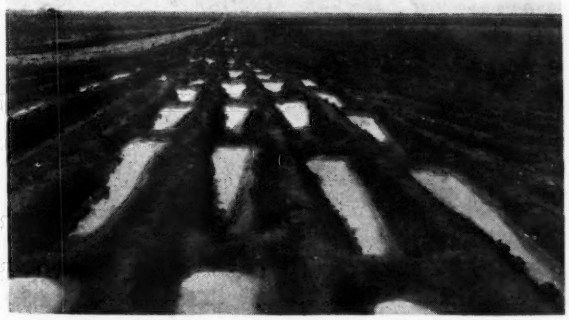
Author: Associate agricultural engineer, USDA Soil Conservation Service. Assoc. Mem. ASAE.



BASIN LISTING IN THE GENERAL DIRECTION OF TERRACES 12 HR AFTER A 2.4-IN RAIN, AT HAYS, KANSAS, IN 1935

TABLE 1. WHEAT YIELDS DEPENDENT UPON MOISTURE IN THE SOIL AT SEEDING TIME

(Depth the soil was wet at seeding time and the resulting yields of winter wheat on the Fort Hays Experiment Station, Hays, Kansas, 1910-1934.)

Soil condition at seeding time	Number of plots seeded	Plots	Yield, bu per acre	Average
		8	Less than 4	
		2	4 to 9	
Dry soil	13	3	10 to 19	5.3
		0	20	
		13	Less than 10	
Soil wet 1 ft deep	22	6	10 to 19	8.3
		3	20 to 25	
		8	Less than 10	
		6	10 to 19	
Soil wet 2 ft deep	24	7	20 to 29	16.9
		3	30 or more	
		1	Less than 10	
Soil wet		3	10 to 19	
3 ft deep	31	19	20 to 29	26.5
or deeper		33	30 to 39	
		5	40 or more	

NOTE: The division of dry land agriculture, U S Department of Agriculture, find a close relationship between yields of winter wheat and the depth the soil was wet at seeding time

and never dry when early fall listed. Water was never stored in the fourth foot in the same period by late fall plowing, three times when early fall plowed, and five times when early fall listed.

The amount of moisture stored in the soil by tillage and the amount of that water used by the wheat crop on continuous wheat and fallow land is illustrated in Table 3.

The wheat plants were able to extract soil moisture down to about 13 per cent, which is the minimum point of exhaustion for this soil, as shown in the July 1 column. The difference between the July 1 and September 30 seeding columns represents the amount of moisture stored by tillage. The difference between the seeding and July 1 after harvest columns is the amount used by the crop. Wheat will usually use the entire amount of available water. When a sufficient amount of water is not available, the yield will usually be reduced as shown in Table 1, unless sufficient and timely rainfall is received.

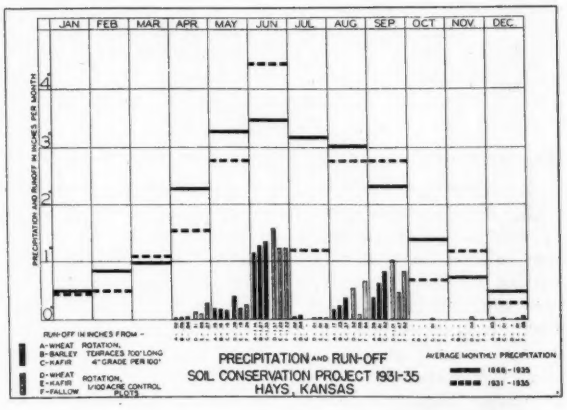
The amount and distribution of runoff throughout the years is illustrated in Fig. 1. The losses are greatest in June and September for both the row crops and small grains. Runoff losses from fallow land increase as the season progresses and reach the peak about seeding time for wheat. The increasing losses are due to fineness of soil, lack of

TABLE 2. EARLY TILLAGE IMPORTANT FOR STORAGE OF MAXIMUM AMOUNT OF WATER

(These figures supplied by the division of dry land agriculture, U S Department of Agriculture, show the number of times in 22 years water was stored to different depths in the soil by three methods of preparing wheat stubble land for wheat at Hays, Kan.)

Soil condition at seeding time	Plowed late after harvest	Plowed early after harvest	Listed early after harvest
Dry soil	12	1	0
Soil wet 1 ft only	3	6	5
Soil wet 2 ft deep	5	7	8
Soil wet 3 ft deep	2	5	4
Soil wet 4 ft or deeper	0	3	5

Average annual precipitation at Hays, Kansas, 1909-1934, inclusive, 22.19 in.



undecayed organic matter, increasing soil moisture, and the smoothness of soil so necessary for an ideal seedbed.

The question remains, how can more water be stored in the soil when growing wheat on the same land each year? Table 2 shows more water can be stored by early tillage immediately after harvest as compared to late fall tillage. The runoff losses from wheat land in June, according to Fig. 1, may be reduced by proper terraces. Tillage can reduce and possibly eliminate all of the runoff losses, except from the heavier torrential rains occurring in July and August. The losses occurring in September and fore part of October may be controlled some by tillage, but more often must be taken care of by proper terraces, the same as in June. Runoff losses from row-crop land can be controlled by tillage prior to planting the crop. After the crop is planted, terraces will be required to control the runoff throughout the growing season although it is hoped that basin tillage cultivation can be perfected to eliminate the runoff losses. Basin lister tillage on fallow land the past few years has been most successful in eliminating all runoff losses. Experimental results are not sufficient to date to make definite conclusions as to the value of this type of tillage, but if the results continue to be favorable, basin-lister tillage will find a definite place in fallow, wheat, and row-crop tillage for soil control and moisture conservation.

TABLE 3. PER CENT OF MOISTURE STORED IN THE SOIL BY TILLAGE AND HOW THAT MOISTURE WAS USED BY THE CROP (WHEAT)

Method	Depth, ft	July 1	Sept. 30 seeding	July 1 harvest	July 1	Sept. 30 seeding	July 1 harvest	July 1	Sept. 30 seeding	July 1 harvest
	1	10.0	13.8	9.8	12.3	16.6	10.4	13.3	18.3	10.0
	2	14.7	14.6	14.6	16.4	16.8	15.8	19.7	19.9	15.5
Late	3	13.9	12.9	13.7	15.2	14.5	15.1	15.0	15.5	15.7
fall	4	13.5	13.1	13.1	14.2	14.0	14.5	15.0	15.1	15.1
plowed	5	14.0	14.1	13.5	14.3	14.0	14.3	15.5	16.5	16.7
	6	14.5	15.4	14.9	15.4	14.0	14.9	16.2	16.9	17.0
	1	11.5	20.7	10.3	12.5	22.6	11.3	21.8	24.9	11.3
	2	15.0	17.0	14.9	15.3	20.2	15.3	25.5	25.9	14.4
Early	3	13.8	14.2	13.2	13.6	16.2	13.9	16.6	19.3	13.3
fall	4	13.0	14.0	13.2	13.1	13.9	13.8	13.1	18.2	12.7
plowed	5	14.0	15.1	14.3	14.2	14.8	15.3	14.4	18.2	14 0
	6	15.0	15.8	15.6	15.2	16.0	17.1	15.8	18.0	15.3
	1	14.4	22.5	12.0	12.0	24.8	11.8	16.9	25.5	16.2
	2	17.0	25.6	15.0	14.6	26.6	14.8	16.2	29.2	16.1
Fallowed	3	14.0	21.4	13.3	12.2	20.7	13.0	13.1	24.1	13.4
	4	13.8	21.1	13.5	12.1	16.3	12.9	12.1	24.5	12.0
	5	15.8	18.6	15.6	14.9	15.3	14.4	12.9	24.4	13.5
	6	17.8	18.6	17.0	16.9	16.7	16.7	13.6	23.4	14.0

(Data from the division of dry land agriculture, Bureau of Plant Industry, U S Department of Agriculture, Hays, Kansas)

The Fundamental Approach to Tillage and Traction Research Problems

By R. W. Trullinger

THE OPERATIONS of tillage and traction are regarded as essential features of modern farming. Both operations, separately and in combination, are known to be immense consumers of power in farming and, as such, are appreciable items in the cost of farm production. Thus adequately designed and properly adapted tillage and traction mechanisms, which will reduce power consumption to a minimum and will perform efficiently, have become economic necessities; the responsibility for providing them rests squarely on the shoulders of agricultural engineers in the research institutions and in the manufacturing industries. It seems worth while, therefore, to examine some of the important basic factors involved in recent accomplishments along this line. Since both tillage and traction begin with the soil, this discussion will be limited to the soil, to the extent that the engineer is concerned, with the idea of exposing some of the problems involved and showing how research engineers are getting at them.

Tillage and traction operations on the farm are concerned with the application of external forces on soil masses to accomplish certain definite purposes, and with the reactions of the soil masses to those externally applied forces. Tillage implies the production of a certain type or degree of tilth in soil, which is adapted to the requirements of the optimum germination and growth of a particular crop. In order to accomplish this result the soil must be moved, ruptured, and distorted into the desired form by applied force from a properly designed and constructed tillage tool. Traction implies the imposition of tractive impulses, either normal or tangential, against given sectional areas or surfaces of soil, with the thought that the soil, by virtue of the strength of its structure, if it has any, and its adhesive and cohesive properties, will resist and, by its reaction to the tractive impulse, will drive the traction mechanism forward.

Thus it becomes apparent that, during the process of tillage of soils having a definite structure, certain strength or resistive properties of the soil structure must be overcome to a degree corresponding to the amount of rupture and distortion required to produce a desired degree of tilth. Likewise in traction it is expected that tractive impulses will be applied to the soil in such a manner that full advantage is taken of the strength and/or resistive properties of the soil and its structure, with minimum rupture or distortion of the structure, and consequently minimum slipping of the traction mechanism and maximum effective tractive effort. It is easy to understand, therefore, why both tillage and traction processes are especially complicated in soils having no structure or cohesive properties, such as very sandy soils.

In dealing with tillage and traction problems, the engineer is concerned primarily with the resolution of the forces involved, not only above ground where it is a comparatively simple process, but especially underground where it is not so simple. It must be recognized at the outset, therefore, that in such an analytical approach the soil is not an inert mass having properties of volume and weight only, but is a living, dynamic body. It is in a state of constant physical, chemical, and biological change and, depending upon its physico-chemical properties, is capable of reacting to externally applied forces in rather definite ways. This has been found true both in soils having structure and in structureless soils, but in varying degrees. To be on sound ground in his analysis, the engineer should know about these things.

For purposes of engineering analysis, the soil must be considered as a dynamic body in a state of equilibrium at the instant forces are applied to it, in the same manner in which one would consider any other material having measurable physical properties which would be involved in resisting external stresses. The obvious reason for this is that in both tillage and traction studies, leading ultimately to the development of the basic principles of design of corresponding mechanisms, it is necessary to measure reactions in the soil to applied forces, which tend to rupture or distort its structure, with reference to their intensity, direction, and resultant, and to integrate this resolution of forces with a similar resolution of forces on the machines themselves. When subjected to such external forces, the soil is momentarily thrown out of equilibrium, and unbalanced internal forces cause it to react in certain definite ways until it again reaches a state of equilibrium. By all means, the engineer developing tillage and traction machinery should know about these reactions; their origin, nature, amount, and direction. They become particularly important in structureless sandy soils having low cohesive properties, where their manifestation is difficult to observe and measure.

More than 35 years ago, King, an agricultural engineer at the Wisconsin Agricultural Experiment Station, showed that plowing with a moldboard plow involved the shearing, lifting, inversion, and pulverization of the soil, all of which occur in opposition to or take advantage of the cohesive, adhesive, frictional, tension, compression, and mass properties of the soil. However, he did not explain the origin or character of these properties or indicate their intensity or direction of manifestation.

A few years later Atterberg, a Dutch engineer and soil technologist, showed that the constituents of clay which impart the properties of plasticity, cohesion, adhesion, tensile and compressive strengths, and toughness have a leafy or scaly structure under the ultramicroscope. He concluded that the strength and resistive properties of soils, which are manifested when the soil structure is subjected to external forces, are properties only of the scaly-shaped particles of colloidal size in the soil. While he also did not explain the reactive properties of soils, he did show the importance, in studies of tillage and traction, of learning the degrees of plasticity, fluidity, stickiness, and resistance to rolling out of soils containing an appreciable percentage of these colloidal particles, because he was able to demonstrate some measurable relationships between the colloidal properties

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Author: Principal agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture. Mem. ASAE.

and these plasticity manifestations. He and several other agricultural engineers and soil technologists in this country found in fact that the strength of clay soils, whether plastic or dry, is due to molecular cohesion of the colloidal clay particles themselves, and that plasticity, which is so important in tillage particularly, is the resultant of the balancing of the forces of cohesion and disruption. These ultimately proved to be important findings in the tillage and traction engineering fields.

Many years later, Nichols, Randolph, Baver, and other agricultural engineers and soil technologists began gradually to get at the underlying explanation of these combination soils-engineering phenomena involved in tillage and traction. Baver again showed that the disk-shaped colloidal particles of soils impart plasticity and the strength properties related to and dependent thereon, and that the plasticity and the related strength properties increase as the content of these colloidal particles increases. He went even further into the matter, however, and showed that these colloidal disks are separated by soil solution films, the tensile strengths of which in the aggregate are immense and form the seat of the tendency and capacity of plastic soils to react when they are distorted or ruptured by applied force. Thus was revealed to the engineer one of the prime nuclei of the strength of soil structure and of its ability to react to stress and resist distortion. In addition, Baver showed that soil colloids offer a powerful electrical system which by proper surface charging holds soil particles and combined moisture together with great force. It appears that much of the cohesive strength of colloidal soils is due to this system.

Nichols and his associates, realizing that tillage and traction must deal with nonplastic soils as well as plastic soils, demonstrated further that the moisture content of nonplastic soils, at which reactions to external rupturing forces occur, varies directly with the content of colloidal particles and that the reactions themselves are due to and governed by the physical forces of the film moisture on and between the colloidal particles. Thus the amount of force necessary to produce a given reaction in a non-plastic soil would vary with the colloid content and the number of moisture films involved. Apparently this principle holds true in nonplastic soils with a minimum of structural manifestation and a minimum of cohesive strength, and this was one of the first tangible methods of approaching the study of tillage and traction in sandy soils.

IMPORTANCE OF CONDITION BASIS RATHER THAN LOCATION BASIS OF SOIL KNOWLEDGE

With this background of fundamental soil physics information, efforts have been made by these and other agricultural engineers to establish basic principles of tillage and traction of wide applicability, so that tests in California, for example, might be interpreted in terms of conditions in Alabama or Pennsylvania. The physical impossibility of testing all the possible shapes and sizes of tillage machines and traction elements in all possible soil combinations has not only been recognized, but the futility of this procedure demonstrated, even if it were physically possible, owing to the lack of tangible bases for explaining results with any one experiment or group of experiments. Anyhow, in tillage, for example, how could an engineer proceed with precision if he did not know the value and direction of the resultant reaction of soil to applied forces? The work of Clyde, an agricultural engineer at the Pennsylvania station, has created the strong suspicion that many of the so-called draft tests were in reality drag tests, without reference to whether the tillage tool was performing properly or not. At any rate, by systematic studies based upon known soil dynamics principles, engineers have been able to show that tillage and traction in soil are accomplished in opposition to or by taking full advantage of such strength or resistive properties of the soil as shear, tension, compression, internal and external friction, cohesion, adhesion, and the like. They also have succeeded actually in measuring these strength properties and, by vector analysis and the use of plaster casts, have been able to show how an externally imposed stress is received by and distributed in a soil, the resulting distortion of the soil and the manner, amount, and direction of the resultant reaction of the soil. Furthermore they have been able to attach all these essentially engineering phenomena to soil science principles as indicated above. and whenever a result is secured it can be explained in tangible terms and when encountered elsewhere under different conditions can be understood and properly utilized. In other words, it is gradually becoming possible to associate stress and strain with the inherent characteristics of various soil combinations in somewhat the same manner as this is done with the various kinds and combinations of metals, woods, concrete mixtures, etc.

SOIL FACTORS INFLUENCING TILLAGE MACHINERY OPERATION AND DESIGN

For example, it has been shown that adhesion, which is the principal soil factor involved in friction between plastic soil and the metal surface of a tillage tool, and in which the designer of tillage tools is chiefly interested, is a function of the soil moisture or soil solution films, and that it is the relative surface tensions of these films which largely govern the intensity of adhesion and hence of friction. Of course high friction means wasted power and probably excessive wear of the tillage tool. Sticking and spreading of the soil solution on a metal surface, resulting in nonscouring or friction, or both, between the soil and the tillage tool, have been found to occur if the adhesion between the two is greater than the cohesion within the soil solution itself, whereas sticking and spreading does not occur and friction is reduced to a minimum if cohesion is greater than adhesion. These phenomena are now known to be attached to the physico-chemical characteristics of plastic soil, regardless of its type or series, and there is more than a strong suspicion that to a certain degree they are related in the same manner to nonplastic, structureless soils through the medium of moisture content, which acts as a cohesive and adhesive medium. The engineer is concerned only with these physical manifestations and what causes them. This suggests that possibly alloying, heat-treatment, or other treatment of the metal, which will reduce adhesion of the soil to a minimum by bringing about intermolecular repulsion, may be the logical approach to the problem of reducing friction, where it can not be done by reducing normal pressure of soil against metal surfaces by shape manipulation. But before expensive practices of this character are entered into, clear objectives, based upon facts as to these dynamic properties and their causes, should be at hand. Likewise, use of the principles of adhesion and friction appears to be at least one of the logical approaches to the problem of wear of tillage tools, especially in plastic soils, and possibly in wet nonplastic soils, since, if there is no adhesional contact, there can be little friction and hence a minimum of wear. It would appear that the most logical and effective way to get at these facts is to learn the truth about the interfacial molecular relationships between soil and metal surfaces.

Since it is unnecessarily tedious for engineers to attempt to explain all tests of tillage and traction mechanisms on

the basis of the intricate physico-chemistry of soils, as indicated above, an intermediary has been sought. It has been found that the so-called plasticity or consistency constants developed by Atterberg, in connection with his studies to explain the strength properties of soils, not only are explainable on the basis of physico-chemical principles and phenomena on the one hand, but on the other afford a simple means of calculating the strength and resistive properties of plastic soils under stress, singly and in combination, such as shear, cohesion, adhesion, compression, etc., with sufficient accuracy for most practical purposes.

For example, it has been possible to calculate the friction curve of any plastic soil for any particular metal surface and the range of compressibility, from the Atterberg consistency constants. It has also been demonstrated that the maximum shear value of any plastic soil is proportional to the plasticity number, and a similar relationship has been established for cohesion. On this basis it has been shown that the maximum resistance, expressed in pounds pull of three soils of widely varying physico-chemical properties, to the passage of tillage tools of known size and shape, is a logarithmic function of the plasticity number.

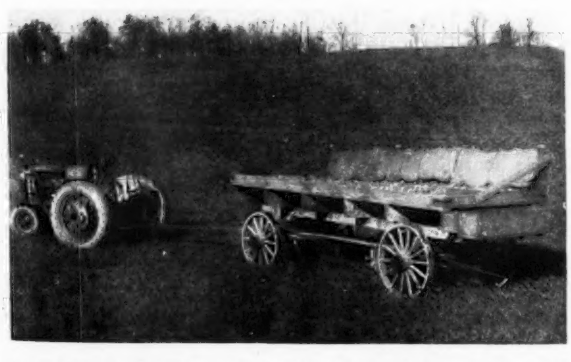
Thus progress is being made toward expressing the values of the physical forces manifested by plastic soils when resisting the operations of tillage and traction fairly accurately in terms of rather definite and fairly easily manipulated constants. It is known that these constants, as functions of the colloidal and other physico-chemical properties of soils, including the exchange phenomena, the moisture content, and the organic matter content, are scientifically sound. These constants are now used widely by engineers wherever soil is involved in the transmission or distribution of externally applied forces or in resisting them, and the work of some 25 or 30 soil mechanics laboratories in this country and in Europe is based upon their use.

With this background of combined soil science and engineering, which indicates the essential character of the properties of soil colloids and of the tension of film moisture in determining the reactions of soils to tillage and traction impulses, progress is being made in interpreting these reactions in terms of measurable physical and mechanical properties of soils, and corresponding tillage tool shapes and traction mechanism design. Work also is underway on the development of essential metal surface characteristics of tillage tools.

Much yet remains to be done. For example, in tillage more definite measures of tilth are needed, which can be expressed in terms of soil science with sufficient precision to provide engineers with tangible objectives for the development of tillage methods, and principles of design of tillage tools for specific crops adapted to certain soils. More must be learned about the interfacial molecular relationships between soils and metal surfaces to provide a tangible basis for the treatment of metals with which to manufacture tillage tools for difficult tillage conditions, and to reduce wear of tools to a minimum. The situation in traction is similar. We are not yet fully informed as to all the things which actually happen when a tractor-driving mechanism transmits a tractive impulse to the soil, and we know less of what to do about it. McKibben, of the Iowa Agricultural Experiment Station, has gradually succeeded in integrating some of the underground mechanics of the situation with the aboveground kinematics, but much yet must be found out, however, to make this story complete.

This apparently tedious and long-drawn-out method of approach to these problems is gradually producing results. It is a method opposed to the cut-and-try and rule-of-thumb methods which already have received such wide trial in efforts to find a short-cut road to the establishment of engineering history. It is a slow, painstaking method, but once a fact or principle is established, it is permanent and engineers will always know the nature, extent and limits of its utility. It is obviously out of the question to test all of the possible designs of tillage tools and traction elements on every conceivable combination of arable soil, and there exists considerable question as to the desirability or efficacy of such procedure unless based upon more sound soil facts than simply empirical observation. The record of such efforts is long and wide and costly, and they have failed in many cases to accomplish permanent results of wide applicability, simply because they have overlooked the important and essential part which the dynamic properties of the soil play in these operations.

The work of research engineers like King, Nichols, Randolph, Reed, Clyde, McKibben, and others is showing that the logical approach to the permanent solution of tillage and traction problems consists of efforts to establish widely applicable basic principles governing the relationship between soil science and force reactions in soils on the one hand, and, on the other hand, to establish similar basic principles governing the relationship between force reactions in soils and the principles of design of implements which will accomplish the desired tillage and traction results in soils of known dynamic properties.



A VIEW OF THE STRAW CUSHION BACKBOARD TO REDUCE SHELLING OF HAND-HUSKED CORN THROWN ON THE WAGON

Wagons for Harvesting Corn

By D. G. Williams

CORN HUSKING is still being done by hand on our farms. Corn is husked from the standing stalks and thrown directly into horse-drawn flats which travel with each husking crew. These flats are equipped with backboards to permit the huskers to gain speed at the expense of accuracy when throwing the corn into the wagon bodies.

A large proportion of the thrown corn struck these backboards and considerable shelling occurred. We remedied this condition to a considerable extent by cushioning the backboards with bags stuffed with straw as shown in the accompanying illustration.

Interior Arrangement and Decoration of Farm Homes

By Ellen Pennell

INSTEAD of telling you my opinions on interior arrangement and decoration of country homes, I am going to relay to you the wishes and expressions of rural homemakers from coast to coast. A home-building contest conducted by "The Country Home" this past spring brought replies from 931 women, telling exactly what they needed and wanted in a modern farm home.

These women are not so modest in their desires for improved homes. They want the latest and the best that is available in house building trends. Their only standard to go by is the new city or suburban home, or the model houses on display at fairs and such places. The progressive homemaker no longer thinks and speaks of building in terms of parlors, pantries, and porticos. She asks for a well-arranged smaller kitchen, with utility room near by. She wants a recreation room for entertainment, parties, and club meetings. She asks for an office for her husband (and he's given her this idea), a work shop for son, a room for her daughter, and a sewing room for herself.

The dining room as such is up for question, even in the rural home. There are many comments favorable to the dining-living-room combination. With this arrangement some prefer a screened-in back porch for serving crowds in summer.

Air-conditioning systems are the subject of many inquiries from our readers.

In the expressions of many, the ideal house must include a basement, fruit and vegetable storage room, backstairs leading to basement and also upstairs, a back hall, a front hall, and an attic, along with the living rooms, bedrooms, and bathrooms. Materials come in for their share of importance. Insulation, weather stripping, fireproof shingles, and siding are a part of their farm vocabulary. Extreme heat and dust storms have doubtless sold much of this material.

There are endless details which homemakers request in the finished house, details that may seem petty, but they add much to the comfort of living. The height of equipment has long been a subject of discussion, to express it mildly. Kitchens will never be completely convenient until equipment is installed according to the height of the homemaker, instead of the height of the plumber or carpenter. The bending, stooping, reaching, and climbing on ladders because the local carpenter had to build according to his mentality has provided more hazards in homemaking and caused more accidents in kitchens than it makes me comfortable to relate. This says nothing of the inconvenience it lends to the daily housework routine.

As for this matter of cupboards, there are so many important details that frequently you may think them petty nuisances, but just the same they add to the ease of meal preparation.

Movable and adjustable shelves are favored. Some shelves should be narrower than others for small items. Wide shelves that hold two rows of articles, which necessitate reaching to the back row for a can of baking powder, always result in a general knocking down of several items that spill all over cupboards and work surfaces, thus making an extra clean-up job which invariably results in ill temper.

Wide articles require wide shelves and small articles require narrow shelves. Racks on cupboard doors will take care of many of the smallest items as salt and pepper, spices, and so on. Platters, trays, and pie, cake and muffin tins fit neatly into upright partition units.

These are just a few requests on cupboards. I realize these requests seem like whims of a child to this audience. After working with farmstead layouts, house and barn plans, etc., cupboard shelves must be almost an insult. Maybe if I appeal to you through better roast beef, more delicious apple pie, and altogether tip-top meals, you will better understand the value of this subject.

There is another important question in the minds of every woman who really lives in her kitchen, and that is arrangement of major pieces of equipment. Since our utility companies have spent time and money building the most efficient kitchens planned by the best home economists and engineers in the country, it would be smart to consider their principles. They recommend that equipment be placed according to meal preparation procedures. This places equipment along two sides and one corner of the kitchen. First the refrigerator, followed by a cabinet with surface to be used in preliminary steps in preparing food, then sink and dish washing center, and next the range with a serving table beside it. From this serving table, food may be carried directly to the dining room. This leaves the other side of the kitchen available for a breakfast table and even a desk if desired.

The equipment that furnishes this kitchen is a real item in the farm home. Every rural homemaker wants a good range, a refrigerator large enough to preserve quantities of food, adequate running water, and cupboard space, and all pieces running smoothly.

The first request from homemakers who were questioned when rural electricity came their way, was for a refrigerator. There were many eager for ranges.

Again I repeat that the desires of the rural woman are not so modest when it comes to furnishing her home, but she doesn't stop merely with the interior. There is the landscaped lawn and the attractive doorway in her mind. So many women ask for ideas to attract guests to come in the front door. There is also a request for the back door to be placed in direct line with gardens and service area of the yard.

As for the decorative side of this problem, her wishes are direct and simple. She wants color, but color that will stay, color that stands cleaning. Painted surfaces are popular, linoleum floors are still favored in kitchen, bath, utility room, and sometimes in halls.

They do not ask for furniture that is elaborate, but it must be comfortable, durable, and attractive, and it must be selected to please every *(Continued on page 24)*

Presented before the Farm Structures Division at the winter meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 1936.

Author: Homemaking editor, "The Country Home."

Characteristics of Transverse Pitot Tubes

By J. E. Christiansen and O. C. French

A TRANSVERSE Pitot tube is a straight tube of uniform diameter with one or more impact orifices for determining velocity head. When used for measuring flow in a pipe line it is inserted through two stuffing boxes in opposite walls of the pipe, being free to rotate and to slide back and forth. The Collins flow gage, a special form of transverse Pitot tube having two orifices on opposite sides of the tube, is widely used for measuring the flow of water in pipe lines, especially for testing irrigation pumping plants in California. The essential features of this tube are shown in Fig. 1. The difference in pressure on the upstream and downstream sides of the tube, which is approximately twice the velocity head, is indicated on a manometer. This arrangement is very convenient for field tests, as no static pressure connection is needed.

The standard Collins tube, being 5/16 in in diameter, occupies an appreciable part of the cross-sectional area of small pipes frequently encountered. Whether or not one should correct for the area thus occupied when calculating the flow is a question not yet satisfactorily answered. One of the power companies using the tube deducts for the area occupied by the tube, and increases the velocity by 4 per cent. There is also the question as to whether the differential head indicated by the manometer is equal to twice the velocity head. Marks[1] states that the impact orifice on the upstream side of a transverse tube registers the exact velocity head with a coefficient of unity; but his tests on a 1/8-in tube in an air stream indicate that the negative pressure on the downstream side of the tube is somewhat less than the positive pressure on the upstream side.

To determine some of the characteristics of transverse tubes and also to answer, if possible, the questions mentioned above, tests were made on four transverse tubes of different sizes, an improvised Pitot tube, and a tube for determining static pressure. The dimensions of these tubes (Fig. 1) are given in the following tabulation:

Diameter of tube, in	Type of tube	Number of orifices	Orifice diameter, in
1/8	transverse	1	0.052
3/16	transverse	1	0.070
1/4	transverse	1	0.070
5/16	transverse (Collins)	2	0.116
3/16 x 1/8	Pitot	1	0.096
3/16 x 1/8	static pressure	2	0.042

Water was circulated through 11 ft of 6-in o.d. casing with a turbine pump. The end of the casing was equipped with a calibrated 4 3/8-in endcap orifice. The flow was controlled by means of a 6-in gate valve, with 1-in bypass valve, maintaining a 60-in head on the orifice, corresponding to a flow of 646 gal per min.

The transverse tube was installed 2 ft 3 3/4 in upstream from the orifice. The static connection was made by drilling a 1/4-in hole through the pipe wall, and inserting and soldering a short piece of 1/4-in copper tubing flush with the inside surface of the pipe wall. The burr on the inside of the pipe was carefully removed. This copper tube was set 90 deg and about 9/32 in upstream from the center of the holes for the transverse tubes. Subsequent tests showed that in this position the static pressure measurement was affected by the transverse tubes, and corrections to the measured differential pressures were made.

Series A tests were made with both stuffing boxes screwed into tapped holes (1/4-in pipe size) in the sides of the pipe (Fig. 1 A). The stuffing boxes were screwed in reasonably tight, no attempt being made to see that they were flush on the inside of the pipe. Another 5/16-in transverse tube was in a parallel position in the pipe 3 ft 1 1/2 in upstream from the tube being tested. The presence of this tube in the pipe was accidental. It had been previously installed but was believed to be too near the gate valve for testing purposes. When the new position was selected this tube was not removed, for it was assumed to be sufficiently far upstream not to affect the velocity distribution at the tube being tested. Series B tests, however, made without this tube in the pipe, show that this assumption was not correct.

According to series A tests (Fig. 2), the velocity curves for the orifice upstream are all similar in shape and position, but the curves for the orifice downstream are erratic, although similar in shape for the 3/16 and 1/4-in tubes, for which the velocity is high near the wall and a minimum about 3/4 in away. The curve for the 5/16-in tube is approximately the same near the right wall but different near the left wall. Further investigation indicated that the shape of the velocity curve for the orifice downstream was materially affected by the position of the stuffing box with respect to the wall of the pipe. To determine this effect, a comparison of the velocity curves was made

Authors: Respectively, assistant irrigation engineer (Assoc. Mem. ASAE) and junior agricultural engineer (Jun. Mem. ASAE), University of California.

[1]Marks, L. S. The determination of the direction and velocity of flow of fluids. Journal of the Franklin Institute 217 (2): 201-212. Feb. 1934.

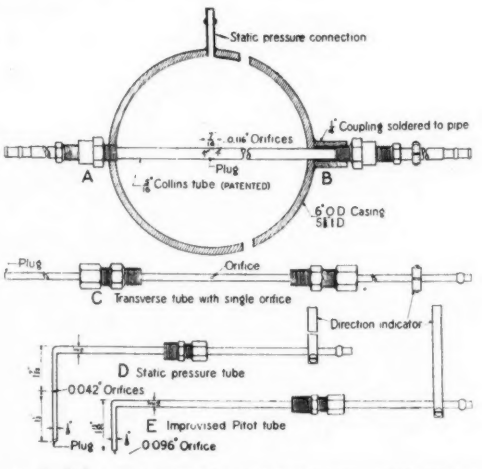
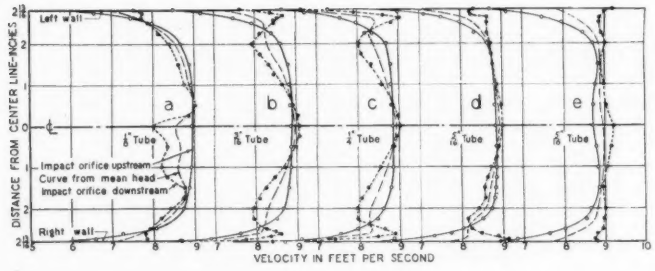


FIG. 1 (A) USUAL METHOD OF INSERTING TRANSVERSE TUBES IN PIPE USED FOR SERIES A, D, AND E TESTS. THE COLLINS TUBE IS SHOWN. (B) SPECIAL METHOD USED FOR SERIES B AND C TESTS. (C) TRANSVERSE TUBE WITH SINGLE ORIFICE. THREE SIZES WERE USED: 1/8, 3/16, AND 1/4-IN TUBE DIAMETERS. (D) TUBE FOR DETERMINING STATIC PRESSURE. (E) IMPROVISED PITOT TUBE USED IN SERIES D TESTS



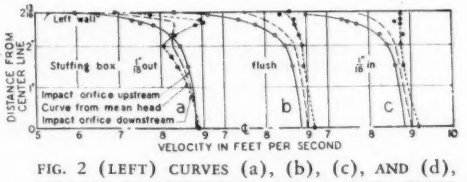


FIG. 2 (LEFT) CURVES (a), (b), (c), AND (d), VELOCITY TRAVERSES FOR SERIES A TESTS; CURVE (e) FOR SERIES C TESTS. FIG. 3 (ABOVE) VELOCITY TRAVERSES FOR HALF PIPE DIAMETER, SHOWING EFFECT OF STUFFING-BOX POSITION WITH RESPECT TO INSIDE OF PIPE

for three positions of the stuffing box for the 5/16-in tube. The results are shown in Fig. 3. Curve (a) shows the result of having the stuffing box screwed out 1/18 in from the inside surface of the pipe wall. For curve (b) the stuffing box was flush, and for curve (c) it projected into the pipe 1/18 in. The similarity of curve (a), Fig. 3, and curves (b) and (c), Fig. 2, is apparent. The stuffing boxes for the 3/16-in and 1/4-in tubes were slightly oversize and were not screwed in flush with the inside surface of the pipe wall.

Series B tests (Fig. 4) were made with the stuffing boxes screwed into 1/4-in pipe couplings soldered to the outside of the pipe 45 deg from the tapped holes (Fig 1 B). The test on the 1/8-in tube was made first. The holes through the pipe wall were drilled just large enough for the 1/8-in tube to be inserted. The burrs were carefully removed from the inside of the pipe before the test was made. On the completion of the test on the 1/8-in tube, the holes through the pipe were drilled out to 3/16 in for this size tube. They were later enlarged to 1/4 in and 5/16 in, respectively. For this series of tests the 5/16-in transverse tube 3 ft 1 1/2 in upstream was removed, and the pipe was rotated so that the traverses were made in a horizontal position except for curve (c), which was vertical. The similarity in the shape and position of the curves for the orifice upstream is apparent. In all cases the velocity for the orifice downstream was somewhat higher than for the orifice upstream.

A test on the 5/16-in tube (series C) was then made with the other 5/16-in tube in position 3 ft 1 1/2 in upstream. In this test the planes of the two tubes intersected at an angle of 45 deg. The velocity curves for this test are shown in Fig. 2, curve (e). For the orifice upstream the reduced velocity at the center and the increased velocity near the wall are due to the presence of the transverse tube upstream.

Another test (series D) was made with the improvised Pitot tube of the dimensions shown in Fig. 1 E. Traverses were made across the pipe from each side. With the impact orifice upstream the two velocity curves were identical and were similar in shape to the curves obtained in series B tests (Fig. 4), except, that the velocity was slightly higher at the center. With the orifice downstream the differential head was roughly one-fifth of that for the orifice upstream, and the curves were different for the two traverses.

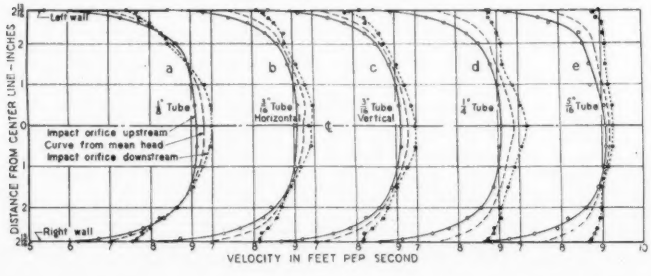
To exaggerate greatly the effect of the area occupied by the tube, tests (series E) were made with a 5/16-in transverse tube and a 1/8-in transverse tube in a 1-in pipe. The 5/16-in tube occupied 39.2 per cent of the pipe area; the 1/8-in tube, 15.4 per cent. The stuffing boxes were screwed into tapped holes in the pipe wall and set tangent with inside surface. The flow was maintained nearly constant, being measured with a 5/8-in displacement type water meter. The velocities were then corrected to a constant flow. The velocity traverses with the orifice upstream are almost identical (Fig. 5). With the orifice downstream, however, the curves are quite different, the minimum velocity being at the center, with the maximum near the pipe walls. This shape may result from the fact that the stuffing boxes with straight ends did not fit the curvature of the pipe wall and small cavities were present above and below the tubes.

The mean velocities calculated from the end-cap orifice measurement for the 5 5/8-in pipe, and from the displacement meter measurement for the 1-in pipe, together with the net mean velocities when the pipe area is corrected for the area occupied by the tube, and for half of this area, are given in Table 1.

TABLE 1. MEAN VELOCITIES CALCULATED FROM MEASURED FLOW

Pipe diameter, in	Tube diameter, in	Flow gpm	Mean velocity—ft per sec: Full pipe area	Corrected for tube area	Corrected for half tube area
5 5/8	1/8	646.	8.34	8.58	8.44
5 5/8	3/16	646.	8.34	8.70	8.52
5 5/8	1/4	646.	8.34	8.84	8.59
5 5/8	5/16	646.	8.34	8.97	8.65
1.04	1/8	12.35	4.66	5.51	
1.04	5/16	12.35	4.66	7.54	

For each traverse the velocities corresponding to the mean differential heads, half the sum of the differential heads for the orifice upstream and orifice downstream positions, were calculated and are shown in dashed curves in Figs. 2, 3, and 4. These mean-head velocity curves are those that would have been obtained with tubes having two orifices diametrically opposite. They are slightly dif-



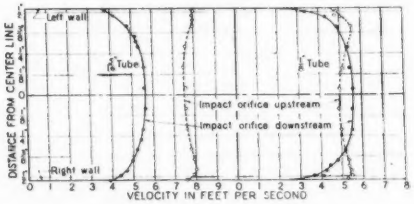


FIG. 4 (LEFT) VELOCITY TRAVERSES FOR SERIES B TESTS. FIG. 5 (ABOVE) VELOCITY TRAVERSES IN 1-IN PIPE, SERIES E TESTS

ferent from those that would be obtained with the Collins tube having orifices 7/16 in apart, although this difference would be negligible except in cases where the orifice downstream curves are erratic (Figs. 2 and 3).

The mean velocity for each traverse was calculated by tabulating the velocities at ten points, each representing the velocity at the midpoint on each side of five concentric rings of equal area. These points occur at 0.316, 0.548, 0.707, 0.837, and 0.949 of the radius on each side of the center. The mean velocities for the orifice upstream check the mean velocity determined from the endcap orifice measurement very closely for all tubes, without any corrections for area of pipe occupied by the tube. For series B tests, the mean velocities for the orifice downstream check fairly closely when the correction for total area occupied by the tube is applied. The mean velocities for the mean-head curves also check very closely when a correction for half the area occupied by the tube is made. A summary of the mean velocities determined from the traverses and a comparison with the mean velocities calculated from the measured flow are given in Table 2.

A two-point method of determining the mean velocity, widely used with the Collins tube, consists of measuring the velocity head at distances of 0.707 of the pipe radius on each side of the center. This is the theoretical position of the mean velocity if the velocity curve is a true parabola. Gibson[2] discusses the results of experiments by Darcy, Bazin, Cole, Morrow, Threlfall, Longridge, Stanton, and others who find the position of mean velocity to vary from 0.69 to 0.80 R, with a mean of about 0.75 R.

The positions of the mean velocities, as determined from the traverses shown in Figs. 2, 4, and 5, are summarized in Table 3.

These positions are fairly consistent with the exception of series A tests on the 3/16 and 1/4-in tubes for the mean-head curves that were affected by the erratic orifice-downstream traverses. The position of mean velocity is somewhat farther from the center for the orifice-upstream traverses for series A and C because of the effect of the 5/16-in tube 3 ft 1½ in upstream. Judging from these tests, the measurements should be made at a distance of about 0.78 R from the pipe center if a two-point method is employed. Differences in velocities at 0.707 R and the mean velocities average + 3.0 per cent for all orifice-upstream traverses and vary from —0.6 to +2.6 per cent for the mean-head velocity curves, averaging +1.1 per cent.

[2]Gibson, A. H. Hydraulics and its applications. p. 211. D. Van Nostrand, New York. 1930.

TABLE 3. POSITION OF MEAN VELOCITY

Series	Tube diameter, in	Average position of mean velocity: Orifice upstream traverse	Average position of mean velocity: Mean-head velocity curve
A	1/8, 5/16	0.81 R	0.78 R
A	3/16, 1/4	0.81	0.68
B	All tubes	0.78	0.77
C	5/16	0.82	0.82
D	3/16 x 1/8	0.78	
E	1/8, 5/16	0.76	

These tests offered an opportunity to study various influences on static-pressure readings. The pressure at the static-pressure connection (Fig. 1) was compared with that obtained with a 1/4-in pipe bushing screwed into one of the tapped holes for the transverse tubes. The pressure at the latter connection depended upon the position of the bushing with respect to the inside of the pipe. With the bushing either flush or back in the pipe wall, the pressure was greater than the true static pressure. As the bushing was screwed into the pipe the pressure decreased and became appreciably less than the static pressure.

Comparisons were also made with pressures at the holes drilled through the 1/4-in couplings for the transverse tubes in series B tests (Fig. 1 B). For each set of holes tests were made both before and after the burrs were removed from the holes. These tests are summarized in Table 4.

In view of the consistent differences it was assumed that the pressure at the static-pressure connection was slightly high, and a correction of —0.15 in was applied to all differential-head readings before the velocities were calculated.

Since the static pressure connection was only 9/32 in upstream from the transverse tubes, tests were made to determine their effect upon the static-pressure readings. A manometer between the static-pressure connection and an auxiliary pressure connection upstream indicated that the pressure at the static connection was reduced by the transverse tubes. The necessary corrections to be applied were as follows: 1/8-in tube, +0.35 in of water; 3/16-in, +0.50; 1/4-in, +0.65; 5/16-in, +0.80.

In many places where transverse tubes are used it is impossible to remove burrs from the inside of the pipe. Since the tests indicated that bushings screwed into tapped holes, or plain holes without the burrs removed, are not

TABLE 2. MEAN VELOCITIES FROM TRAVERSES AND DEPARTURES FROM VELOCITIES CALCULATED FROM MEASURED FLOW*

Series	Diameter of pipe, in	Diameter of tube, in	Orifice upstream: Velocity, ft per sec	Orifice upstream: Departure, per cent	Orifice downstream: Velocity, ft per sec	Orifice downstream: Departure, per cent	Mean-head curve: Velocity, ft per sec	Mean-head curve: Departure per cent
A	5⅝	1/8	8.41	+0.8	8.30	—3.3	8.36	—1.2
A	5⅝	3/16	8.36	+0.2	8.32	—4.4	8.35	—2.0
A	5⅝	1/4	8.37	+0.4	8.35	—5.5	8.37	—2.6
A	5⅝	5/16	8.39	+0.6	8.60	—4.1	8.50	—1.8
B	5⅝	1/8	8.36	+0.2	8.53	—0.6	8.45	—0.1
B	5⅝	3/16	8.33	—0.1	8.77	+0.8	8.55	+0.4
B**	5⅝	3/16	8.34	0.0	8.80	+1.1	8.57	+0.6
B	5⅝	1/4	8.30	—0.5	9.08	+2.7	8.70	+1.3
B	5⅝	5/16	8.35	+0.1	9.02	+0.6	8.69	+0.4
C	5⅝	5/16	8.39	+0.6	8.94	—0.3	8.67	+0.2
D	5⅝	3/16	8.35	+0.1				
E	1.04	1/8	4.86	+4.3	5.23	—5.1		
E	1.04	5/16	4.99	+7.1	7.79	+3.3		

*For the orifice upstream the departures were calculated from the velocity for the full pipe area; for the orifice downstream, departures were calculated from velocities corrected for tube areas; and for the mean-head curve, departures were calculated from velocities corrected for half the tube areas.

**Vertical traverse.

TABLE 4. COMPARISON OF STATIC PRESSURE DETERMINATIONS AT HOLES DRILLED THROUGH PIPE WALL FOR SERIES B TESTS

Diameter of hole, in	Pressure difference*, in Left connection		Right connection	
	With burr	Burr removed	With burr	Burr removed
1/8	—1.05	—0.20	—1.10	—0.20
3/16	—0.05	—0.05	—0.70	—0.25
1/4	—0.15	—0.10	—1.15	—0.13
5/16	—1.75	—0.15	—1.20	—0.10
Average		—0.125		—0.17
Average all holes				—0.15

*The negative signs indicate that the pressures were less than at the static-pressure connection.

reliable, some accurate method of determining the true static pressure is necessary if the orifice upstream traverse only is to be used. Conventional Pitot tubes take the static pressure from small orifices on the side of the tube projecting upstream. The static pressure tube with two No. 58 drill holes (Fig. 1 D) yielded pressures only 0.05 to 0.1 in higher than at the static-pressure connection. This difference is possibly due to the orifices being too large, conventional tubes having four to six smaller orifices. With a reliable instrument that could be inserted in a tapped hole, accurate field measurements could be made where other methods would be questionable.

Tests to determine the pressure distribution around transverse tubes were made in a 5⅝-in pipe with a 5/16-in tube, and in a 1-in pipe with both ⅛ and 5/16-in tubes (Fig. 6). With the orifice at the center of the pipe, readings were taken at each 10-deg rotation of the tube. As the tube is rotated from the upstream position through an angle of about 15 deg, the pressure varies but little from the maximum. With further rotation it decreases rapidly, equaling the static pressure at approximately 45 deg and reaching a minimum at about 80 deg. Beyond 90 deg it is almost constant, increasing slightly near 180 deg.

The pressure distribution around transverse tubes can be utilized to determine the true direction of flow in the following manner: Set the orifice at 45 deg from the upstream position, and read the differential head. Rotate the tube to the opposite side of the upstream position until the same differential head is obtained. The true direction of flow will be midway between these two positions. Marks has used a transverse tube with three orifices for this purpose. There is no satisfactory way, however, of using a transverse tube to determine the true static pressure.

SUMMARY AND CONCLUSIONS

1 Negative pressures on the downstream side of transverse tubes were generally greater than positive pressures on the upstream side.

2 Velocity traverses with the orifice upstream were identical for all tubes, regardless of size, and were similar to those obtained with an improvised conventional type Pitot tube. Mean velocities computed from these traverses agree with the endcap orifice measurement.

3 Orifice-downstream traverses were affected by the position of the stuffing boxes with respect to the pipe wall. Mean velocities computed from these traverses approximate the velocities calculated from net pipe areas after deducting for areas occupied by the tubes.

4 Tests indicate that velocities determined from the mean-head for orifice-upstream and orifice-downstream positions should be corrected for half the area occupied by the tube.

5 Positions of mean velocity were found to average

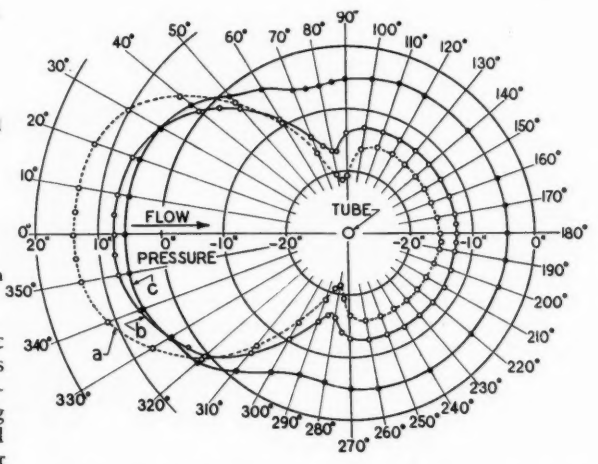


FIG. 6 PRESSURE DISTRIBUTION AROUND TRANSVERSE TUBE: (a) 5/16-IN TUBE IN 5⅝-IN PIPE; (b) 5/16-IN TUBE IN 1-IN PIPE; (c) ⅛-IN TUBE IN 1-IN PIPE

0.78 of the radius from the center of the pipe. Average differences between velocities at 0.707 R and mean velocities were +3 per cent for orifice-upstream traverses and +1 per cent for mean-head velocity curves.

6 Static-pressure connections made by drilling holes through the pipe wall were not reliable before the burrs were removed. A bushing screwed in a tapped hole gave erroneous results. A static-pressure tube inserted in a tapped hole proved satisfactory for static-pressure determinations.

7 When properly used, transverse Pitot tubes are reliable devices for measuring the flow of water in pipes. The tests indicate that measurements within one per cent of the true discharge are possible.

AUTHORS' NOTE: Since submitting the manuscript of this paper, a paper entitled "Piezometer Investigations," by C. M. Allen and L. J. Hooper, in Transactions of the American Society of Mechanical Engineers, Vol. 54, May 15, 1932, has come to our attention. This investigation supplements and confirms our tests on static pressure measurements.

Interior Arrangement and Decoration of Farm Homes

(Continued from page 20)

member of the family. They realize that farm homes are lived in and used daily, so all decorative touches must be livable.

There is a real craving for color and beauty in the home, as evidenced by the use of too much of it in many cases. There must be light in the house. Light from color of the interior, and windows which permit light and a view from the exterior.

There is one thought I hope to leave with you. When considering houses, think of those who are going to build. There are many who have the money, and even more desire than money. All they need is encouragement and help. They cannot depend upon local carpenters and material dealers. Every agency must come to the rescue of the country home. You in your work, building companies in their fields, and editors in theirs. Remember if you will help and instruct, the farmer will build, and build well.

The challenge is ours. If farm homes are not greatly improved within the next ten years, it will not be the farmer's fault, but ours.

The Development of a Low Cost Hay Drier

By J. W. Weaver, Jr.

ACCORDING to census figures[1], about one million tons of hay were produced in the Tennessee Valley area in 1929, and 1½ million tons of hay were fed in the same area in 1930, indicating that farmers in the area purchase annually, either directly or indirectly, about a half million tons of hay. There is then justification for artificial drying of hay, not only for the additional half million tons which can be grown in the Tennessee Valley, and which would have to be of equal or better quality than that which is imported from other sections, but also for the improvement in quality of the million tons now grown each year.

Successful commercial driers have been on the market for a number of years, selling at a minimum of about $3,500. It is evident that only a large hay farmer can afford such an investment, and it is a fact that the bulk of hay grown in the Tennessee Valley area comes from smaller hay farmers, growing about 20 tons annually. These farmers might afford a hay drier that would save and improve the quality of their crop, if the cost of the drier was not over several hundred dollars.

It is normally possible, as determined by numbers of observations, to cut hay in the morning after the dew has evaporated, let it lie in the swath for 2 or 3 hr, siderake and leave it in windrows for another 2 or 3 hr, thus subjecting it to from 4 to 6 hr of field drying, which will reduce the moisture content from 75 per cent when cut to 35 or 45 per cent by late afternoon. Every farmer knows that, if his hay could be stored away on the same day it was cut, the rain hazard would be almost eliminated, its quality would be much improved, due to less bleaching by the sun, and the routine of farm work would not be disrupted to any great extent; but hay of 40 per cent moisture content is not suitable for storage. This means that an additional 25 per cent or more of moisture must be removed after one day of field drying before hay can be stored away. It is well known that hay of 40 per cent moisture content can be readily handled without losing any of the leaves[2], the most valuable part of the crop.

With these facts clearly in mind, it has been the objective of this project to take advantage of nature's method of drying in the field for one day; and deliver the partially cured hay, with leaves intact, to an inexpensive drier capable of removing 25 per cent or more of moisture, and so arranged that it would be practical for the 20-ton hay farmer (Fig. 1).

The first work done in this development employed a 1-hp electric motor, which was belted to a centrifugal blower. Air was delivered through a duct containing a 5-kw chromalox airblast heater. The air was forced through the hay from a central slatted chamber 9 ft long, 3 ft high and 4 in across. This chamber was made of 2x4 members standing on end and slatted down the side with wood lath. It was centrally located along the long axis of an 8x14-ft platform. Partially cured alfalfa hay from the field, with 40 per cent moisture, was placed on the platform similar to a load of hay. Air was blown up through the chamber and filtered out through the hay. The 5-kw electric heater was used to warm the air at night. After 22 hr of drying, the moisture content was reduced to 19 per cent. One other test was conducted in a similar manner, using partially cured hay of 50 per cent moisture, in which case 48 hr were required to reduce the moisture content to 20 per cent. The resulting hay was of good uniform quality and green color.

Another series of tests was conducted in the fall of 1934, using a small gasoline engine to drive the blower described above connected through a duct to the hollow center of a small hay stack, similar to experiments carried on in Scotland[3] and at Purdue University[4]. Alfalfa hay of

Paper presented before a meeting of the Southern Section of the American Society of Agricultural Engineers at Jackson, Miss., February 6, 1936, and supplemented with a report of continued experiments during the summer of 1936.

Author: Assistant agricultural engineer, agricultural engineering section, Agricultural Industries Division, Tennessee Valley Authority. Jun. Mem. ASAE.

[1]Fifteenth Census of the United States: 1930, Agriculture, Tennessee, First Series. Superintendent of Documents, Washington, D. C.

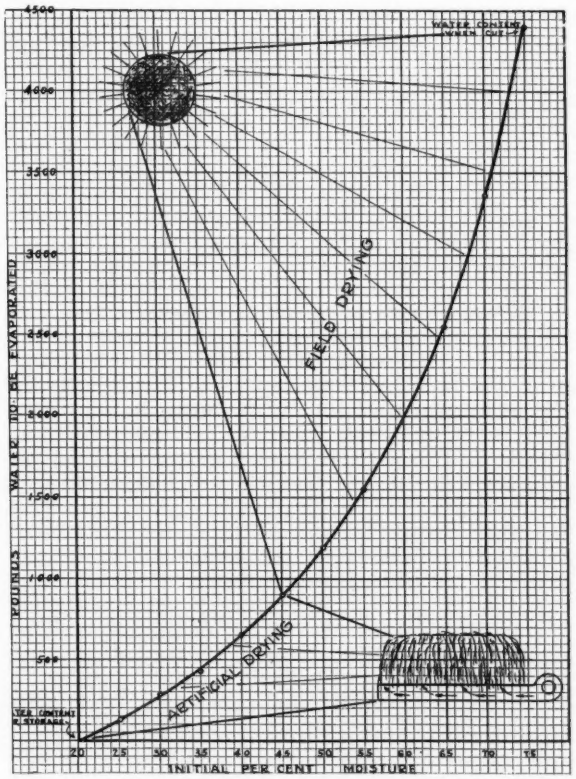


FIG. 1 THIS CURVE SHOWS THE POUNDS OF WATER THAT MUST BE EVAPORATED FROM LEGUMES OR GRASSES OF 25 TO 75 PER CENT WATER CONTENT TO MAKE ONE TON OF HAY OF 20 PER CENT WATER CONTENT

[2]Moisture Content at Which Alfalfa Leaves Shatter by Frank. J. Zink. Agricultural Engineering, vol. 17, no. 8, August 1936.

[3]The Proctor Tripod Harvesting System. The Implement and Machinery Review, November 1, 1931.

[4]Some Stack and Grain Drying Results, by William Aitkenhead. AGRICULTURAL ENGINEERING, vol. 8, no. 8, August 1927.

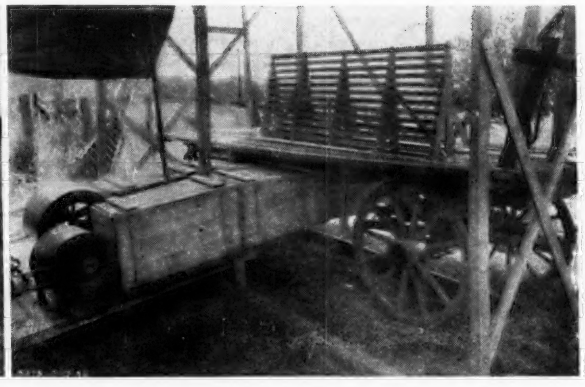


FIG. 2 (LEFT) HAY PARTIALLY REMOVED TO SHOW INTERIOR OF STACK. NO ARTIFICIAL HEAT USED. FIG. 3 (RIGHT) AIR DUCTS, EACH ENCLOSING AN ELECTRIC HEATER, CONNECTED TO WAGON-CURING RACK

about 65 per cent moisture content was used to make up the stack in these tests, and air was blown through the stack from 4 to 6 hr daily. It was found that air could be forced uniformly through a volume of hay, but that this method was not successful with hay of such high moisture content, the hay heating and spoiling before its moisture content could be reduced to a safe point for storage (Fig. 2).

It was then thought probable that partially cured hay from the field could be loaded in the afternoon, on wagons with special hay frames, hauled to a blower or blowers, and, by attaching air ducts and blowing warmed air through the hay, finish the drying cycle by morning. Thus by a combination of natural drying in the field, supplemented with artificial drying at night, it was hoped to work out a practical system using only wagons, blowers, heaters, and motors, with interconnecting ducts between the wagons and blowers, and still preserve the leaves and quality of the hay.

Accordingly in June 1935 another series of tests was started, using two electric motors and two centrifugal blowers. Air was delivered through two ducts containing electric heaters to an A-frame chamber located in the center of a hay wagon, as shown in Fig. 3. Four tests were conducted with this setup, using partially cured alfalfa hay with moisture content ranging from 39 to 44 per cent. The electric heaters were used only after sundown, and in the last test were not used at all. A good quality of hay resulted from all four of these tests, but the time required to bring the moisture content down to a safe point for storage was too great to fit into the system outlined above. Observations showed that by using one 10-kw and one 5-kw heater, one in each duct, it was possible to raise the entering air temperature only about 10 F (degrees Fahrenheit) and to lower its relative humidity about 20 per cent, which approximated daytime air conditions. By adding more heat the drying quality of the air could have been improved, but the cost of operation would have been prohibitive.

Observation made in the foregoing tests led to the adoption of another system of drying. By blowing air up through partially dried hay stored in a barn to a depth of 6 to 10 ft, it was thought that much of the heat requirement for warming the air could be eliminated by blowing only during the daytime, or periods of low humidity. This system would require a longer drying time. However, with the hay permanently stored under shelter, the time element was not considered as important as in the previous system. It was also hoped that after drying the first cutting of hay, the second cutting could be stored in the same barn, making another layer of hay, to be dried by blowing air up through both layers.

Consequently, a series of tests was started on July 24, using the same arrangement of motors, blowers, and heaters. A tight floor was built into the skeleton shelter and its sides and ends were boarded up tight, forming a miniature hay mow 10x16 ft (Fig. 4). The A-frame chamber was removed from the center of the floor and a slat floor placed 4 in above the tight floor, allowing the air coming from the blowers to have access to the entire bottom area of the hay. This arrangement was made as a precaution to try out the system in the open before making a barn installation and running the risk of spontaneous combustion. Three tests were conducted with this setup, when it was found that the majority of the air was escaping up along the side walls. The slat floor was then boarded tight 18 in in from each side wall to cut off this escape. Four more tests were conducted, after which it was found that the 12-in blower and motor would supply ample air to care for the 10x16-ft mow.

A trial of drying hay in layers was started on September 25, when a quantity of partially cured alfalfa hay was placed in the mow on top of a batch of previously cured hay, filling the mow about 10 ft deep. The results of this trial were not conclusive but proved very promising.

The last series of tests in 1935 proved most valuable, as they were conducted in a practical application for the 20-ton hay farmer, based upon the experience of foregoing tests. Twenty tons of loose hay would cover a 20x40-ft floor space approximately 12.5 ft deep. A main duct 16x16 in and eight lateral ducts 10x12 in, with sides open one inch up from the bottom, were constructed to cover a floor space of 20x40 ft (Fig. 5). A 16-in centrifugal blower was placed at one end of the main duct and belted to a 5-hp electric motor. The main duct enclosed a series of adjustable gates, so that air could be blown intermittently into any combination of laterals desired.

A hay mixture of clovers and grasses, with a moisture content of 38 per cent was placed over the ducts to a depth of 5 ft on September 20. The blower was started at 5:00 p. m., and was left running until noon September 23. No heat was used during this test. Air was blown intermittently into alternate laterals on both sides for periods of 2 hr during the three days. Approximately 7 tons of hay were dried with a maximum demand of less than 3 hp.

Prior to the haying season of 1936 the duct system as outlined above was enlarged to cover a floor space of 40x40 ft. The 5-hp motor was replaced by one of 3 hp to drive the 16-in blower at 1300 rpm (revolutions per min-

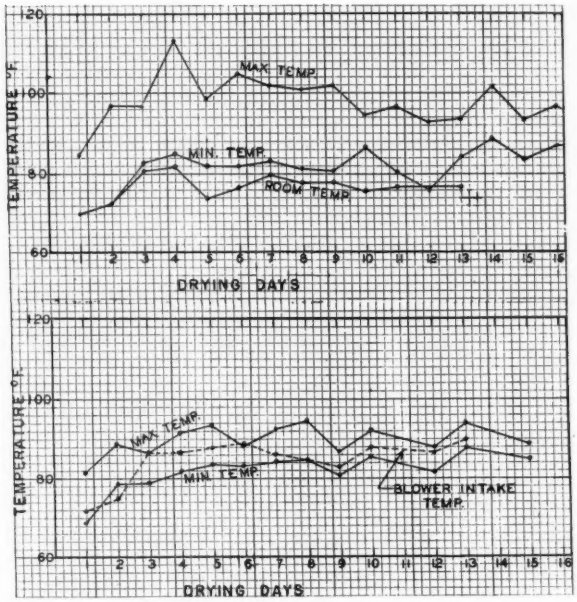


FIG. 6 (TOP) TEMPERATURE VARIATION WITHIN HAY (BLOWER "OFF"). FIG. 7 (BOTTOM) TEMPERATURE VARIATION WITHIN HAY (BLOWER "ON")

ute). The 10-kw heater was removed from the main duct to cut down the resistance to air flow. It was not found necessary to use any artificial heat during the 1936 season.

In May 1936 alfalfa hay containing about 20 per cent lespedeza, clovers, and grasses, was placed over this duct system, varying in depth from 4 to 6 ft. About 3 tons of dried hay of good color and aroma resulted after operating the blower intermittently between 8:30 a. m. and 9:00 p. m., over a period of seven days, a total of 58¼ hr, using 108 kwh (kilowatt-hours), or about 35 kwh per ton of dried hay, in reducing it from a moisture content of 43.3 per cent to 15.8 per cent.

In August 1936 alfalfa hay was placed over the hay cured in May to a total depth varying from 6 to 12 ft. About 9 tons of dried hay of fair color and aroma resulted after operating the blower intermittently over a period of 15 days, for a total of 74½ hr, using 141.2 kwh, or about 16 kwh per ton of dried hay, in reducing it from a maximum of 45.6 per cent to 17.2 per cent moisture content.

During the last series of tests a potentiometer was used for observing temperatures within the hay at fourteen different points, taking three readings at each point from top to bottom of the hay. From these readings a set of temperature curves has been drawn to summarize observations. Fig. 6 shows maximum temperature variation within the hay just prior to starting the blower each morning and following its nightly period of "shutdown," averaging 17½ hr. Fig. 7 shows maximum temperature variation within the hay following about 5 hr of blower operation.

Maximum temperatures as indicated in Fig. 6 could readily be reduced to the neighborhood of outside air temperatures, as determined by numbers of observations, after 5 to 10 min of blower operation. Minimum temperatures usually fell below blower intake air temperatures while the blower was in operation.

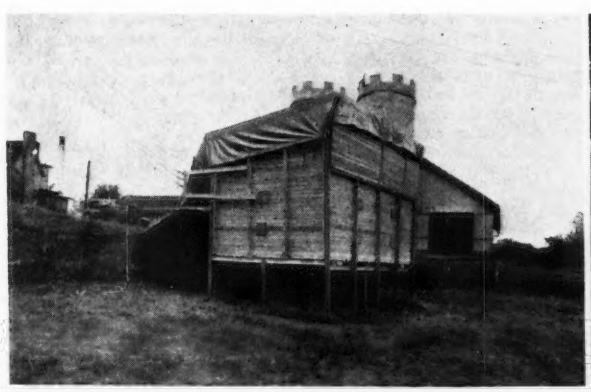
Due to a short hay crop, only two tests were conducted with this system during the 1936 season, as compared with fourteen preliminary tests for the season of 1935. The cost of this last installation, including the 3-hp motor, blower, 10-kw heater, lumber, hardware, wiring material, and labor, would approximate $300.

Attention should be called to one test in which partially cured alfalfa hay was brought in from the field following a shower of rain and was placed in the mow (Fig. 4) having a moisture content of 50 per cent. After 6 days of drying the moisture content was 20 per cent. This hay dried out slightly dusty and one spot was quite brown in color, but it was readily eaten by stock. Incidentally, about 10 acres of alfalfa were cut at the same time as that used in the test and lay in the field through four days of heavy rainfall. Needless to say, this hay was a total loss, and the same thing occurred with 15 acres of clover hay.

Observations of the barn-drying tests are as follows:

1 The kilowatt-hour consumption of electricity per dry ton varied greatly throughout the entire group of tests, dependent largely upon initial moisture content of hay, variety of hay used, air conditions, and the need for observations requiring power beyond that necessary to complete the normal drying cycle. Further observations are necessary before any definite average figure can be given, and then it will vary with the variety of hay being dried.

2 Little difficulty was experienced in drying clean hay of the small stem varieties, such as alfalfa and lespedeza. The higher the grass content in the hay, the more difficult it was to dry. The large stem *(Continued on page 46)*



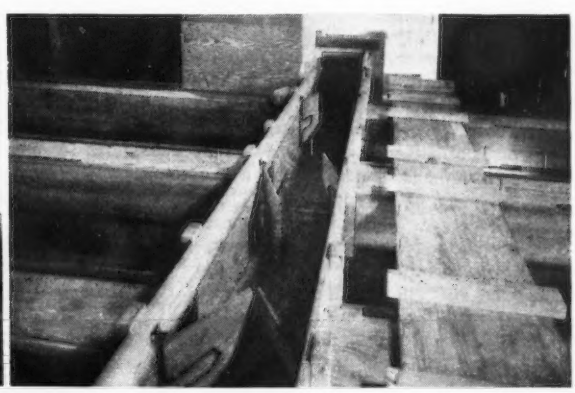


FIG. 4 (LEFT) MINIATURE HAY MOW, 10X16 FT, CONTAINING A FALSE SLATTED FLOOR UNDER WHICH AIR WAS DELIVERED FROM A 12-IN BLOWER. FIG. 5 (RIGHT) HAY DRIER IN BARN AT UNIVERSITY OF TENNESSEE. COVER OF MAIN DUCT REMOVED TO SHOW GATES AT EACH OUTLET. GATES ARE CONTROLLED BY RODS EXTENDING THROUGH THE FLOOR OF THE HAY MOW

Supplemental Irrigation in the Humid Region

THE Committee on Supplemental Irrigation of the American Society of Agricultural Engineers has endeavored to compile somewhat more detailed estimates of supplemental irrigation in the various states of the humid region than have been obtained before. The Committee herewith submits its report showing the information secured.

TABLE 1. SUMMARY OF ACRES IRRIGATED, BY METHODS AND STATE

State	Acres irrigated by sprinkling	Acres irrigated by porous hose	Acres irrigated by surface methods	Acres sub-irrigated	Acres irrigated, but type indefinite	Total acres	Reported by
Ala.	3,000		1,000		500	4,500	A. Carnes
Ark.			150,000			150,000	D. G. Carter
Conn.	350		5			355	A. E. Wilkinson
Del.	10					10	G. L. Schuster
Fla.****					62,827	62,827	County Agents
Ga.	300	100	100	1,000	500	2,000	W. N. Danner, Jr.
Ill.	300	30	300			630	E. W. Lehmann
Ind.	500	50				550	T. E. Hienton
Iowa					1,000	1,000	ASAE Committee 1931
Kans.*	400	100	23,500	500	500	25,000	W. G. Ward
Ky.	36	8				44	J. S. Gardner
La.	50		361,000			361,050	E. B. Doran
Maine	90				8	98	H. C. Swift R. M. Riley
Md.	250		800		100	1,150	R. W. Carpenter
Mass.***	2,000					2,000	P. W. Dempsey
Mich.	2,500	2,500	500	100	2,000	7,600	Geo. Amundson
Minn.	750	20	50		75	895	O. W. Howe
Nebr.	550	50	193,650	50	200	194,500	I. D. Wood
N. H.	Quite a little						W. T. Ackerman
N. J.***	6,000					6,000	E. R. Gross
N. Y.	1,500	50	125	150		1,825	B. B. Robb
N. D.*	500	50	500			1,050	H. F. McColly
Ohio	2,000	2,500	2,500	2,100	1,000	10,100	V. Overholt
Okla.			1,573			1,573	L. E. Hazen
Pa.	300					300	
R. I.	200					200	G. E. Adams
S. C.	200			1,000	25	1,225	H. P. Cooper
S. D.**	15		158		100	273	R. L. Patty
Texas*	2,500		103,970			106,470	H. P. Smith
Vt.	2	5				7	H. N. Stapleton
Va.	2,000		1,500		100	3,600	C. E. Seitz
W. Va.	20		100			120	F. D. Cornell, Jr.
Wis.***	300	20	20			340	E. R. Jones
Total	26,623	5,483	841,351	4,900	63,935	947,292	
Total acres irrigated						974,292	
Less acres in rice						613,970	
Acres irrigated, exclusive of rice						333,322	

*East of 100th meridian **East of Pierre

***Does not include cranberry irrigation—approximately 6,000 acres in Massachusetts, 3,600 in New Jersey, and 2,000 in Wisconsin

****Area irrigated from wells does not include area irrigated from other sources.

For the purpose of this report, the dividing line between the eastern humid and the western arid states has been taken as the 100th meridian because, while somewhat arbitrary, it seems a reasonable line of demarkation. Although the large areas irrigated in the borderline states of Nebraska and Kansas largely dominate the figures for acreage irrigated, as is natural, owing to the relatively scanty rainfall even in the portions of those states which lie to the east of the 100th meridian, there is still an impressive acreage under supplemental irrigation in other humid states. The large area irrigated in Florida is impressive, if one considers that the average annual rainfall in that state approximates 52 in.

Table 2 gives the figures for sprinkling irrigation equipment, with some suggestions as to the crops on which this type of irrigation is generally used. As this kind of equipment has probably not been installed for an average cost of less than $300 per acre, it appears that the total investment in this type of irrigation is not less than $8,000,000.

TABLE 2. SPRINKLING SYSTEMS

State	Acres	Crops
N. J.	6,000	Vegetables, small fruits, nursery stock
Ala.	3,000	Vegetables
Mass.	2,000	Vegetables
Ohio	2,000	Vegetables, flowers
Va.	2,000	Vegetables*
Mich.	1,500	Vegetables, small fruits, flowers, potatoes
N. Y.	1,500	Vegetables, small fruits, flowers
Minn.	750	Vegetables, small fruits, special crops
Nebr.	550	Vegetables, nursery stock
Ind.	500	Vegetables
N. D.	500	Vegetables, small fruits
Kans.	400	Vegetables, flowers
Conn.	350	Vegetables
Ill.	300	Vegetables
Wis.	300	Vegetables, small fruits
Md.	250	Vegetables, nursery stock
R. I.	200	Vegetables, florists plants
Me.	90	Vegetables, small fruits
S. D.	15	Landscape plants and tree propagation
Del.	10	Nursery stock
Vt.	2	Vegetables, small fruits, potatoes
Total	22,217	

*Details available — salads, cucumbers, beets, parsley, lettuce, tomatoes, egg plant, celery, cantaloupes.

Table 3 shows a number of specified crops in the different states irrigated by flooding or furrow type irrigation for those states where data is available. It is interesting to note that there is considerable irrigation of orchards (principally apples, we believe) in the several states, and that the irrigation of alfalfa is reported from Virginia.

TABLE 3. FLOODING AND FURROW IRRIGATION

State	Flooding irrigation	Furrow irrigation
Ala.	1,000 acres vegetables	500 acres vegetables
Ark.	150,000 acres rice	
Conn.		5 acres vegetables
Kans.	1,000 acres sugar beets, alfalfa, corn and vegetables	12,000 acres sugar beets, alfalfa, corn and vegetables
La.	360,000 acres rice	1,000 acres truck crops, sugar cane
Md.	800 acres orchard	100 acres various crops
Mich.	150 acres orchard	300 acres vegetables, small fruits, orchards
Minn.		50 acres vegetables, small fruits and special crops
Nebr.	50,000 acres alfalfa, beets and corn	
N. J.	A very little vegetables, small fruits, nursery and field crops, orchards	A very little (same as flooding)
N. Y.		Some vegetables and small fruits
Ohio		2,000 acres vegetables and fruits
S. D.		158 acres gardens, tree propagation
Va.	1,200 acres orchard, alfalfa and general	300 acres orchard, alfalfa and general
Wis.	10 acres pasture	10 acres pasture

A contribution (June 1936) of the ASAE Committee on Supplemental Irrigation — Geo. Amundson, R. Boonstra, B. O. Childs, W. N. Danner, Jr., E. R. Gross, C. E. Seitz, I. D. Wood, and F. E. Staebner (chairman)

What Agricultural Engineers Are Doing

Reported from USDA Bureau of Agricultural Engineering

ON November 12 the members of the Washington office staff held a birthday luncheon in honor of George M. Warren, associate hydraulic-engineer, who retires December 1. His fellow workers presented him with an arm chair as a token of the occasion.

Mr. Warren, a graduate of the Worcester Polytechnic Institute, entered the Department service in 1909 as office engineer in drainage investigations, then a part of the Office of Experiment Stations. He is a member of the Boston Society of Civil Engineers.

Mr. Warren is author of 10 publications of the Department, which to date have had a combined circulation of 1,750,000 copies. Most of these publications relate to drainage, farm water supply, sanitation, and plumbing.

* * *

The following are the work accomplishments reported by the Central District CCC Drainage Camps for October: 2,230,239 cu yd of excavation and embankment, using 33,336 man-days; 5,945,502 sq yd of clearing, using 36,104 man-days; 42,458 linear ft of tile lines reconditioned, using 4,605 man-days; 12,667 man-days used in doing miscellaneous work such as repairing outlet structures, seeding levees, and rebuilding fences. The estimated commercial value of work performed during October was $567,516.64, and the cooperation furnished by the various districts totaled $113,487.01.

* * *

W. W. McLaughlin arrived at New York, October 23, after visiting England, Scotland, Holland, Germany, Denmark, and Sweden. In addition to the International Snow Survey Conference at Edinburgh, which he attended, one of the highlights of the trip from an engineering and agricultural standpoint was a visit to the Zuider Zee Reclamation Project in Holland, where he was shown over the project by the chief engineer. A series of dikes has been constructed for the purpose of cutting off an arm of the North Sea, the area then being drained, thereby creating at least three land units of from 50,000 to nearly 400,000 acres each and an inland lake, the sea water of which is gradually being drained off and replaced by fresh water. The first land unit of 50,000 acres is completed and a considerable part of it is in crops. The land is sufficiently sweetened for cropping in from 2 to 4 years. The hotel at Slootdorp, at which Mr. McLaughlin stayed, was built on ground that 2½ years before was under the sea. At present, farms in the reclaimed area are rented. The final land policy had not yet been determined.

Another project of interest was the 7,000-acre sewer farm maintained by the City of Berlin, which produces from 30 to 40 per cent of all the vegetables used in that city, two or three crops being grown on the same land each season. The sewage is pumped into small settling reservoirs, and the effluent, without treatment, is distributed to the land through ditches about 12 to 16 in deep and 8 to 15 ft apart. It is a sort of subirrigation system for the purpose of fertilization of the soil. The farm units are rented to German farmers who operate under direction of the manager appointed by the city.

* * *

Wells A. Hutchins is preparing a preliminary report on state water laws as affecting the activities of the Soil Conservation Service in Arizona, Colorodo, Nevada, New Mexico, Utah, and Wyoming. This work is being done in cooperation with the Soil Conservation Service, Region 8.

* * *

On the irrigation water supply forecasting project, George D. Clyde reports that soil-moisture determinations were made at all snow courses on the Logan River watershed prior to the occurrence of the fall and early winter precipitation. All cabins in northern Utah and on the Virgin River were stocked for the winter's work. In Colorado, eight additional snow courses were established under the supervision of R. L. Parshall.

* * *

A report by S. W. McBirney on the year's work on sugar beet planting equipment has just been completed. The planter which was used for the experimental plantings, showed some improvement over the regular planters in common use, but it is still far from being as good as hand planting in securing uniform germination stands with a high percentage of single seedlings. The use of the smaller sizes of screened seed resulted in higher percentages of singles, but the average of all sizes of screened seed was no better than unscreened seed.

* * *

W. M. Hurst and Geo. Stafford recently made field observations of soybean harvesting machinery in the vicinity of Elizabeth City, North Carolina, and Norfolk, Virginia. Small combines are being used in those areas to some extent, but horse-drawn machines of the stripper type are still in demand. A single-row, horse-drawn soybean combine with all moving parts driven by a gasoline engine is also apparently giving satisfactory performance. Horse-drawn machines are in demand because of the lack of tractors and the small acreage of beans on many farms.

* * *

J. W. Rockey has been appointed junior agricultural engineer in the Division of Structures and reported for duty November 16 to take up work on farm water supply and sewage disposal heretofore handled by George M. Warren.

* * *

On the Rio Grande joint investigation for the National Resources Committee, field work on consumptive use of water, under the direction of Harry F. Blaney, was concluded November 30 and the preparation of progress reports covering observations in different parts of the Rio Grande Valley was begun. Paul A. Ewing spent the greater part of the month in the Valley, leaving Albuquerque in company with Mr. Blaney November 25 for Berkeley, stopping at Salt Lake City to confer with Dr. O. W. Israelsen in regard to the report the latter is preparing on past studies of consumptive use of water in Rio Grande Valley. Mapping of the vegetative cover in the San Luis Valley, under the direction of Carl Rohwer was completed, the total area mapped during November being 375,000 acres. Aerial photographs were found to be of great assistance in mapping the irregular fields, cut up by marshes, lakes and streams. Field mapping of New Mexico areas was also completed, and the entire crew of mappers was transferred to the office work preparatory to delineating and tabulating field data, which work will probably be finished in December. It is planned that Messrs. Blaney, Ewing, Rohwer, and Israelsen will compile the report on the Rio Grande investigation in the Berkeley office. Fred C. Scobey will remain at Santa Fe until area figures are available for incorporation in the final report.

* * *

Studies of rate of capillary flow of moisture in soil are being continued by M. R. Lewis, three WPA assistants having been furnished for this project. Tests are being made on 72 cores of Chehalis loam soil. The work being done this year is designed to bring out the fundamental relation between the rate at which the moisture content of the soil changes from point to point, and the capillary force which tends to move moisture from wet soil to dry soil. It is hoped to do this by making comparisons between the gravitational force drawing water downward through soil cores, and capillary forces moving moisture through the same or similar soil cores of varying moisture content.

* * *

A general summary of progress on the cooperative wheat storage project is as follows: The purpose of these investigations was to learn what types of storage structures would best preserve and improve the quality of wheat stored on the farm, and what grades of wheat could be safely stored for long periods. There were over 200 lots of grain under observation in all types of storage structures, ranging from a few to over 1,000 bushels each.

A total of 125 farm bins were studied in which records were kept of the temperature by means of thermocouples, the grain being sampled at the time it was placed in the bins and again in the late fall. At four of the college stations various methods of ventilation were studied.

According to the data obtained it is apparent that wheat of over 15 per cent moisture content is unsafe for storage, except possibly under very favorable conditions. The critical moisture content, below which wheat will keep safely in farm bins, has not been determined but is probably well below 15 per cent. It is influenced by the maturity of the grain. Other important factors affecting keeping quality are the construction and ventilation *(Continued on page 32)*

Contributions Invited

All public-service agencies (federal and state), dealing with agricultural engineering research and extension, are invited to contribute information on new developments in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

NEWS

ASAE Winter Meeting Draws Large Attendance

A RECORD attendance of around 400 persons, including more agricultural engineering minded visitors than ever before, gathered for the winter meeting of the American Society of Agricultural Engineers at the Stevens Hotel in Chicago, November 30 to December 4. Nearly 25 per cent of all ASAE members attended.

In the grain storage symposium only inconclusive results could be reported, due to the unusually dry summer which provided little high-moisture grain for moisture removal and storage tests. The consensus of opinion seemed to be that observations should be continued in a year providing more normal moisture conditions.

Literally, the dirt of "dirt farming" was the main subject of technical scrutiny in the opening Power and Machinery Division session. The papers and discussion offered represented a scientific outlook on the nature and handling of soils and attendant tractor and tillage problems, as highly complex subjects basic to progress in tractor and tillage machine design. Progress reports by J. W. Randolph and I. F. Reed on work of the USDA Bureau of Agricultural Engineering's Farm Machinery Laboratory at Auburn, Alabama were particularly well received.

E. R. Jones led a round table discussion Monday evening, November 30, of the Midwest Farm Building Plan Service and how it should be handled in the future. Henry Giese reported the project to date a technical and financial success, with administrative difficulties pointing to some new method of handling details of publication of a needed new edition. A round of discussion developed a general agreement that the Society be asked to take over the publication problem; preparation and technical editing of plans, specifications, the plan book, and material lists to remain a function of the farm building specialists in the agricultural engineering departments of the cooperating colleges.

Tuesday morning's symposium on the small, all-purpose tractor drew out genuine constructive engineering viewpoints on farm use requirements and design considerations in meeting those requirements.

H. C. Merritt put challenge after challenge up to agricultural engineers and the farm equipment industry in a good-natured way in his address opening the afternoon session. He called for better tractors at lower prices; for the horse to be put completely out of the picture as a source of farm power; for economic power alcohol development; for "improving the economic basis for farm prosperity by lowering farm production costs;" and for additional attention to the engineering problems of disease and insect pest control.

R. U. Blasingame, as president of ASAE, responded to the challenge with an appreciation of the contribution of industry to America's material and social progress and an appeal for more complete understanding between representatives of the farm equipment industry and agricultural engineers in public service.

Air conditioning developed as a neat summarization of a major purpose of farm dwellings, animal shelters, and storage buildings, in Tuesday's Farm Structures Division sessions, with papers featuring means, problems, materials, instruments, and research in the field.

Two papers and a lively round of discussion on farm homes Wednesday morning analyzed the improvement problem down to a need of more extension effort directed to retail building supply dealers and rural buil builders, as the present factors limiting farm home improvement.

The joint session symposium on "Chopped Hay and Hay Silage Processing and Storage" uncovered considerable progress in the problem of making hay whether the sun shines or not. Thought was directed from hay as a conventional item of farm economy, to the fundamental matters of forage foods and food values for farm animals, and handling and storage problems, methods, and costs in conserving and utilizing such values.

References were frequent, particularly in the Farm Structures and Power and Machinery Division sessions, to the need of greater cooperation between agricultural engineers and other subject matter specialists, between agricultural engineers in public service and those in industry, and between agricultural engineers in separate states presenting similar agricultural engineering problems. The inference was not that there had been no such cooperation, nor that its possibilities suffered a lack of appreciation, but rather that growing demands on agricultural engineers for additional work and quick results make its application now particularly timely.

When the scene shifted Thursday to rural electrification and soil and water conservation, rechecking of objectives in those fields with emphasis on the importance of sound engineering, was distinctly noticeable. Progress was reviewed and the future considered with emphasis on research and proven applications. The view was implied by some that ballyhooing the importance of these fields, and what can be expected of them, had been done perhaps too well. There was no question evident as to the importance of basing further progress on the soundest engineering possible.

The soil and water conservation meeting reflected current interest and support of that work, with strong emphasis on terraces, terrace outlets, and drop-inlet culverts; and on the search for additional basic facts—physical, biologic, and economic—relating thereto.

Growing interest and opportunity in control of wind erosion, in engineering planning of farm layout and production programs to increase operating efficiency, and in supplemental irrigation for humid regions were revealed in individual papers. L. A. Jones' paper on drainage research showed even that ancient branch of the work still faithfully on the trail of basic facts.

Electricity's intriguing versatility was recounted before the Rural Electric Division but failed to lure the group from their primary interest in the orderly progress of knowledge and its application. Specific farm applications; technique, materials, and equipment; the trends of electrification progress; research; and load building policy occupied most of the time and attention of the division.

The symposium on "Building Load on Rural Lines" turned up numerous differences in practices, methods, policies and personnel problems, many of them imposed by local conditions, company administrative direction, or other factors beyond immediate agricultural engineering control, but no obstacles beyond ironing out into sound rural electrification practice and progress.

Space does not permit detailed comment on individual papers, which will be published in due course. One significant fact about the whole meeting was that definite, clear-cut challenges were put to agricultural engineers in each division and accepted cheerfully, not complacently, but as satisfying recognition and support of the valuable technical service they are prepared to give.

Nominations for 1937-38 ASAE Officers

THE Nominating Committee of the American Society of Agricultural Engineers—J. B. Davidson (chairman), E. E. Brackett, and Wallace Ashby—has placed in nomination the following members in connection with the annual election of officers for the Society year 1937-38:

For President

ARNOLD P. YERKES, editor "Tractor Farming," International Harvester Co.

For First Vice-President

F. C. FENTON, professor of agricultural engineering, Kansas State College

R. C. MILLER, professor of agricultural engineering, Ohio State University

For Second Vice-President

E. C. EASTER, agricultural engineer, Alabama Power Company

G. A. RIETZ, in charge of rural electrification, General Electric Co.

For Treasurer

RAYMOND OLNEY, secretary of the Society

For Councilor

C. A. BENNETT, senior mechanical engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture

C. E. RAMSER, senior soil conservationist, in charge of watershed and hydraulic studies, Soil Conservation Service, U. S. Department of Agriculture

For Nominating Committee

F. P. HANSON, Caterpillar Tractor Co.

E. M. MERVINE, USDA Bureau of Agricultural Engineering

M. M. JONES, University of Missouri

J. B. KELLEY, University of Kentucky

C. P. TOBIN, The Celotex Co.

F. J. ZINK, Allis-Chalmers Mfg. Co.

The By-Laws of the Society provide that thirty days shall be allowed for additional nominations by special nominating committees, at expiration of which period (February 20) the Secretary of the Society will mail letter ballots to all voting members.

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

THE Bureau of Public Roads announced the initiation of a study in November of the causes of highway accidents and conditions contributing to them. It is being made under the Act of Congress in June 1936 authorizing an expenditure of $75,000. The results of the survey are expected to serve as a basis for future safety legislation. Those in charge of the work will be assisted by a strong advisory committee of representatives from other government bureaus, universities, research foundations, safety councils, and automobile associations.

State highway departments are reported to have received a total of $902,010,000 for all highway purposes in 1935. Of this, $589,818,000 was paid in by highway users by registration fees, gasoline taxes and tolls from bridges and ferries. Federal allocations amounted to $219,381,000, and $20,366,000 was derived from counties and other sources. $55,883,000 was secured through the sale of bonds and notes, and $16,562,000 came from all other sources. Thirteen states had transactions exceeding twenty-five millions.

The housing division of the Public Works Administration reports a continuation of its struggle to effect lower construction costs. In addition to the rejection of bids where they appear to be excessive, they take time to revise their own plans, and in some instances to redesign buildings for slum clearance.

During November PWA announced the allotment of $2,760,000 to the Imperial Irrigation District of El Centro, California, for the construction of the first unit of the All-American Canal Power Project. The Power Canal was contemplated in the Boulder Canyon Project Act. It will extend 80 mi to tap the Colorado River 15 mi north of Yuma, Arizona. The water power potentialities include four power sites capable of generating a relatively large amount of electrical energy for the Imperial Valley, which is now served by the Southern Sierra Power Company, a subsidiary of the Nevada California Electric Corporation.

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The Resettlement Administration seems most likely to abandon many of its present activities, and there is a possibility that most of its present activities may be transferred to other agencies having permanent status. It is too early to accurately size up the situation, but the submarginal land purchase program seems certain to go to the Department of the Interior. Land utilization and the rehabilitation of distressed farm owners and tenants may go back to the Department of Agriculture. Farm debt adjustment may be returned to the Farm Credit Administration. Suburban and rural housing is being studied for possibilities of merging it with other housing activities. Mr. Tugwell's sudden resignation and the President's absence leaves the actual future of the Resettlement Administration an open question. Even the transfer of WPA drought cases to it does not indicate extension of life.

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The U. S. Department of Agriculture announced in November that the farmer's cash income from farm marketings amounted to $5,224,000,000 for the first nine months of 1936. This was a gain of 18 per cent over the total for the same period in 1935. All regions showed gains ranging from 13 per cent in two southern regions to 26 per cent in west north central states. Kentucky was the only state showing a decrease. West Virginia and Montana held without material change. Maine showed a gain of 80 per cent, due largely to the increase in income from potatoes.

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Works Progress Administration officials have little to say about the future. It is a fact, however, that the trend of thought and action is toward retrenchment and the reduction of overhead expenses. WPA officials are making a nation-wide survey with the object of curtailing expenses to the degree that the need for relief has diminished. Cuts are expected in administrative personnel and among nonrelief workers, where they will entail minimum hardship and be most effective from the viewpoint of economy.

Unofficial reports indicate dismissals before January 1 running up to 175,000. Of that number, 20,000 are expected to be nonrelief workers and some 5,000, administrative employees. In that connection, it is interesting to note that only one out of every 93 persons working on relief projects is an administrative employee, and that dismissals are likely to be about 1 in 35. In addition to improving the efficiency of the Works Progress Administration, the actual execution of such policies will return many political appointees to private life.

The very strong indication remains, however, that Mr. Hopkins will urge the President to ask Congress for another $500,000,000 to continue WPA activities through June 30, 1937. This will probably be termed "drought adjustment" by congressional appropriation, and it may upset Secretary Morgenthau's assurances that no new taxes or increases in present tax rates are necessary because anticipated revenue yield with the continued recovery will be sufficient to cover expenses.

* * * *

At no time in recent history has there been so much genuine interest in the use of a merit system in government service. The Administration is said to encourage a "career service" to settle the more efficient of "the faithful" into places of influence. Administrative officers welcome it as a means of freeing themselves from personnel difficulties and inefficiency forced upon them by patronage, and employees who prefer government work hope to find in it the opportunity to prove their fitness for permanent positions. The Civil Service Reform League, American Public Welfare Association, the several organizations of government employees, and the professional groups, as well as the general public, all seem equally enthusiastic about the possibilities of substituting personal merit for political or social preference in the selection of public employees.

Council's committees are being informed of this activity and of the related opportunity to improve the economic status of engineers in national, state, and local government service by supporting the merit system. The staff is using its contacts with congressional committees, the Civil Service Commission, and the Civil Service Reform League to promote the universal adoption of the merit system in the form of an expansion of civil service to include a more effective career service. In that connection, we suggest that all engineers in government service and the general public welfare may benefit from publicity given the current campaign for legislation to substitute fitness for political preference.

In the meantime, the elimination process is quietly moving thousands of emergency employees, including hundreds of engineers, into other activities.

Southern Section Invites Meeting Attendance

ALL AGRICULTURAL engineers and other interested persons who desire to do so are invited to attend the meeting of the Southern Section of the American Society of Agricultural Engineers, to be held at the Andrew Jackson Hotel in Nashville, Tennessee, February 3, 4, and 5.

The meeting is in conjunction with the annual meeting of the Association of Southern Agricultural Workers. Announcement of the program was published in AGRICULTURAL ENGINEERING for November 1936. All four major technical branches of agricultural engineering are represented in the program.

Pacific Coast Section to Feature Land Use

LAND USE will be looked at from various angles by agricultural engineers at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at Berkeley, California, February 5 and 6, 1937. Following an address of welcome by C. B. Hutchinson, director of the California Agricultural Experiment Station, at the opening session Friday afternoon, February 5, there will be eight papers and addresses presenting various viewpoints on land classification and land-use problems.

Fred C. Scobey will cover "Technique in Mapping as Related to Land Use." R. Earl Storie is to present "The Place of Soil Studies in Land Classification and Land Use." "Land Utilization from the Irrigation Engineer's Viewpoint," is scheduled for presentation by Martin R. Huberty, associate irrigation engineer of the University of California.

The fifteenth yearly business meeting of the Section will close the afternoon session.

An informal dinner and evening session will feature an address on "The Geographer's Methods of Mapping and Evaluating the Economic and Physical Factors in Land Use," by Carl O. Sauer, professor of geography, University of California.

Saturday morning the Section is to hear Walter Mulford, professor of forestry, University of California, on "The Forester's Approach to Land Utilization;" David Weeks, associate agricultural economist in Giannini Foundation, on "The Economist's Approach and Objectives in Land Utilization;" Jonathan Garst, regional director of the Resettlement Administration, on "Practical Applications of Land-Use Planning in Developed Agricultural Areas;" and Hugh Pomeroy, advisor to county planning commissions, on "The Probable Future of Zoning as Related to Land Utilization."

J. P. Fairbank will be chairman of the Friday afternoon session; W. W. McLaughlin for the dinner program; and Frank Adams for the Saturday morning session.

Farm Mechanization in SAE Program

A TRACTOR session has been scheduled as a feature of the Society of Automotive Engineers' annual meeting at Detroit during the second week of January. Harry G. Davis, director of research of the Farm Equipment Institute, will address the session on "Some Sociological and Economic Aspects of Agricultural Mechanization."

At the same meeting a tractor testing code developed by a committee of members of both the ASAE and SAE is to be submitted to the general standards committee of the SAE for its approval. The same code has been submitted to the ASAE for its approval and adoption as a recommended practice.

What Agricultural Engineers Are Doing

(Continued from page 29)

of the bin, its exposure to sunshine and wind, and the temperature and humidity of the air. Little difference between bins constructed of various materials was found in the tests this year but bins ventilated by perforated bottoms or by means of horizontal flues covered with fly screen kept the wheat in better condition than did unventilated bins. However, these results need to be confirmed by experiments under more normal weather conditions.

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The following publications were issued during the past month:

Annual report of the Bureau, 1936.

Oil Burners for Home Heating, Circular 406, by Arthur H. Senner.

Equipment for Applying Dust Fungicides, Circular 415, by W. M. Hurst, F. D. Fulton, W. R. Humphries, and R. W. Leukel.

Combine Harvesting, Farmers' Bulletin 1761, by W. M. Hurst and W. R. Humphries.

ASAE Meetings Calendar

February 3 to 5, 1937—Southern Section (in conjunction with annual convention of the Association of Southern Agricultural Workers)—Nashville, Tenn.

February 5 and 6, 1937—Pacific Coast Section—Berkeley, Calif.

June 21 to 24, 1937—Annual meeting of the Society—University of Illinois, Urbana-Champaign.

Necrology

WILLIAM NICHOLAS RUMELY, retired engineer, inventor, and manufacturer of farm machinery, castings, and machine tools, passed away at his home in Chicago, November 24, at the age of 78. Mr. Rumely was elected an honorary member of the American Society of Agricultural Engineers in November 1933. He was born into the industry, his father being Meinrad Rumely, founder of the M. and J. Rumely Company, of La Porte, Indiana, pioneer manufacturers of threshing machines and steam traction engines. After a period of technical training and apprenticeship he entered active work in the company and progressed successively to superintendent and engineer, vice-president, and president. He also organized and bought interests in other manufacturing companies. He invented and was granted patents on twenty-seven or more devices, including threshing machines, internal-combustion tractors, clover hullers, friction clutches, steam boilers, steam traction engines, pneumatic stackers, and improvements on such equipment. He was long a member of the American Society of Mechanical Engineers and of the Franklin Institute. Mr. Rumely is survived by his widow, Mrs. Anna Rumely, two sons, and two daughters.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the December issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Wm. J. Dwyer, chief engineer, Avery Farm Machinery Co., Peoria, Ill.

F. R. Elliott, development engineer, The F. E. Myers & Bro. Co., Ashland, Ohio.

Marcus M. Farley, president, Duplex Machinery Co., Battle Creek, Mich.

Arthur J. Ferguson, vice-president, National Electric Screen Co., Chicago, Ill.

W. V. Hukill, agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

D. B. Krimgold, associate soil conservationist, Soil Conservation Service, U. S. Department of Agriculture.

John R. Orelind, experimental engineer, Minneapolis-Moline Power Implement Co., Moline, Ill.

Ellen Pennell, editor, homemaking department, "The Country Home," New York, N.Y.

Fred F. Shafer, inspector, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

Miles H. Tuft, in charge of experimental department, John Deere Wagon Works, Moline, Ill.

Edwin C. Welch, farmer owner, Little Orchard Farm, Antioch, Ill.

Roy S. Whitehill, rural electrification department, Elmira Light, Heat & Power Corp., Elmira, N. Y.

Henry E. Wichers, associate professor, department of architecture, Kansas State College, Manhattan, Kans.

G. L. Ziemer, superintendent, U. S. Emergency Conservation Work, Drakesville, Iowa.

Carlton L. Zink, engineer-in-charge, tractor testing, department of agricultural engineering, University of Nebraska, Lincoln.

Student Branch News

Missouri Student Branch

OUR Branch met December 10 with about thirteen members present. The first part of the meeting was occupied by a talk on "Farm Power Contracting" given by Ted Harper, a student member. Ted related the results of some questionnaires which were sent to some contractors in California, France, and England, and discussed some of the possibilities.

After this discussion the Branch discussed the possibilities of organizing an agricultural engineering fraternity on this campus. No definite decision has been reached regarding the matter as yet, but it seems to have some good possibilities and was favorably received by the boys.—*Joe Park, Secretary.*

Virginia Student Branch

OUR first meeting for the month was held on November 5. At this time student talks were given on the subjects, "Comparison of Diesel and Gasoline Power," "Soil Conservation in Italy and United States," and "Speaking."

At our second meeting the student speakers had for their subjects "The Electric Fence," "Electric Floral Culture," and "Sound Health Knowledge and Habits." At this meeting our course advisor informed us that plans for two of the additional units of the proposed $150,000 agricultural engineering building had been approved and that construction would begin at once.

The Branch was invited to attend a moving picture sponsored by the Electrical Engineering Curricula Club, to take the place of our third meeting, but due to delay of receiving the film this picture was not shown until later.—*S. P. Marshall, Jr., Scribe.*

Idaho Student Branch

THIS Branch has held five meetings since the beginning of the school term. Very briefly the dates of the meetings and what took place are as follows:

October 15, 1936—Introduction of faculty and students; election of officers, and discussion of the program for the coming meeting of the Pacific Coast Section of the American Society of Agricultural Engineers to be held October 30 at Moscow, Idaho and October 31 at Pullman, Washington.

October 27, 1936—Discussion of the Pacific Coast Section program by Mr. Kulp, notice of Society dues, discussion of methods to improving attendance.

November 13, 1936—New members present for first time introduced, discussion of possibility of a joint meeting with Washington State College Student Branch, discussion of agricultural engineering publication, and future meetings of the Branch set for the second and fourth Friday of each month.

November 25, 1936—Discussion of "Agricultural Engineers' Work in Irrigation Projects," by E. H. Neal, graduate of the University of Idaho and at present general manager of the Aberdeen Springfield Canal Company, and announcement of engineering smoker to be held in the Armory.

In addition to the above meetings, the Branch took an active part in the meeting of the Pacific Coast Section of the American Society of Agricultural Engineers. Student attendance at the various meetings, the luncheon, and the banquet was large. Herschel Klaas, president of the Branch, addressed the luncheon.—*Marvin Aslett, Scribe*

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

SOIL COMPACTION CONTROL FOR ROLLED EARTH DAM CONSTRUCTION, *R. R. Proctor.* Jour. Amer. Water Works Assoc., 28 (1936), No. 1, pp. 134-141, figs. 6. Testing procedure is described together with typical test results which bring out the fact that saturated plasticity of the compacted soil is much more important than watertightness alone. From these tests the plasticity needle test was developed. The needle is used to measure the plasticity of the experimentally compacted specimens, and, with such results available for a particular soil, the moisture content of the soil can be found by compacting it in a container, measuring the penetration resistance, and referring to the penetration resistance curves that had been previously prepared. This probably is the most important single use of the needle, as it enables the quick determination of soil moisture content in the field without delay caused by the slowness of oven drying. The entire test requires about 2 minutes.

WHEN IS A TRUCK TIRE OVERLOADED? *J. E. Hale.* SAE Automotive Engin. Jour., 38 (1936), No. 1 Trans., pp. 25-44, figs. 31. Lengthy consideration is given to tire overloading, with the understanding that overloading as referred to in tire failures is quite different from the application of the term overload to structural materials which collapse under a reasonably well-defined excess of load.

A discussion also is included of various other phases of the tire business intended to be instructive along the line of longer life and greater freedom from trouble. The increasing varieties of service in which motor vehicles are being placed demand different types and characteristics of tires, which are outlined. A discussion is included of the relative merits of the balloon type versus high-pressure tires. The choice of tires for new trucks is covered in a practical way and also there is a section outlining the variations of the basis for determining loads and air-pressure recommendations. For the truck operator's benefit, there is included a section as to what the operators should know and practice to get the most out of tires, discussing the importance of inflation, dual mating, wheel alignment, repairs, and retreading on both tires and inner tubes.

A STUDY OF THE ECONOMICAL LOADING AND OPERATION OF MOTOR TRUCKS, *A. J. Scaife.* SAE (Society Automotive Engin.) Jour., 38 (1936), No. 1, Trans., pp. 1-10, figs. 9. A large amount of data is analyzed and discussed, indicating that it is poor economy to operate a motor truck out of its class by overloading.

ELECTRIC MOTORS FOR FARM MACHINERY. *F. E. Rowland.* Rural Electrifi. and Electro-Farming, 11 (1936), No. 129, pp. 287-291, figs. 5. Technical data are presented on the subject.

RURAL SANITATION, *H. E. Miller, et al.* Amer. Pub. Health Assoc. Year Book, 1935-36, pp. 230, 231. This is the annual report of the Joint Committee on Rural Sanitation of the Conference of State Sanitary Engineers, the American Society of Agricultural Engineers, and the American Public Health Association. It deals with the community sanitation projects developed in 24 states under the Civil Works Administration, which involved the installation of over 500,000 sanitary privies and over 5,400 septic tank, sewage disposal systems.

THE TESTING OF TIMBERS AT THE FOREST PRODUCTS RESEARCH LABORATORY. (Gt. Brit.) Dept. Sci. and Inlus. Res., Forest Prod. Res. Rec. 1 (1935), pp. [2] + 8, figs. 2. The purpose of this publication is to explain the character and scope of the timber-testing work of the laboratory and to demonstrate the practical advantages thereof.

USE OF GRAPHITE TO PREVENT CLOGGING OF DRILLS WHEN SOWING DUSTED PEA SEED. *E. L. Arnold* and *J. G. Horsfall.* New York State Sta. Bul. 660 (1936), pp. 23, figs. 5. Studies are reported which showed that the introduction of a thin layer of a nonlubricating dust fungicide, like red copper oxide, between the interfaces of seeds increased the friction between them. In the case of peas the added friction may be so much as to clog and break grain drills of the internal force-feed type.

This friction between treated seeds, the factors that govern it, and the correction of the trouble with lubricants, especially graphite, were studied in the laboratory using single, hand-cranked, standard drill cups and other seeding machinery. The number of turns necessary to pass a uniform lot of seed through the cup gave a usable index of friction.

The index of friction was found to vary with the dosage of red copper oxide, with mixing time, and with moisture content of the seed. The lubricating effect of 325-mesh flake graphite applied at treating time reduced the friction between dusted pea, cabbage, and wheat seeds in proportion to the dosage. It usually required approximately half as much graphite by weight as fungicidal dust to reduce the friction to normal. Talc, air-floated mica, and carbon black were worthless as lubricants.

This friction between dusted seeds causes them to flow less rapidly through drilling machinery than undusted seeds. As a consequence the stand of plants per foot of row may be thinner from treated than from untreated seeds, especially if decay organisms do not reduce the stand from the untreated seeds. Thus the study indicates the importance of considering the effect of seed protectants not only on drilling machinery but also on the seeding rate.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE NEBRASKA STATION. Nebraska Sta. Rpt. (1935), pp. 5-7, 34. Progress results are briefly presented on tractor testing and on investigations of pneumatic tires for farm tractors, electric power on Nebraska farms, electrically heated hotbeds, insulated electric brooders in uninsulated poultry houses, methods of cooling milk on farms, bindweed eradication machinery, and irrigation pumping.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE COLORADO STATION. Colorado Sta. Rpt. 1935, pp. 17-19, 27-30. Progress results are briefly presented of investigations on oil-gravel mixtures for road surfaces, sugar beet machinery, irrigation equipment, and pumping for irrigation.

DUST EXPLOSIONS DURING FIRE FIGHTING. *D. J. Price.* U. S. Dept. Agr. Circ. 385 (1936), pp. 10, figs. 10. Practical information is presented on the prevention of dust explosions during fire fighting.

HOW THE PLOW WORKS. *M. L. Nichols.* Assoc. South. Agr. Workers Proc., 35 (1934), pp. 210, 211. A brief progress report is presented of studies at the Alabama Experiment Station on plow-moldboard operation and basic factors involved in moldboard shapes. All moldboards were found to be divided functionally into thre sections, including the cutting share, a central pulverization area, and a turning and inversion area at the top.

It was found that the entire surfaces of all plows studied could be described by arcs of circles moving along and rotating on or directly above the line of travel of the tip of the wing. Some plows required two arcs; others required only one to describe the surface. A mechanism was devised for measuring the angle (Φ) of the plane of the arc and the line of travel, the angle (θ) produced by the elevation of the free end of the chord of the arc, and (t) the distance of travel. The entire surface was described by parametric equations giving the relationships of the angles Φ, θ, and t, which are expressed by the general formula θ or $\Phi = ce^{kt}$.

It was found that the perpendicular differential sections of the pulverization area for all plows studied could be expressed by the type formula $z = ae^{bx}$.

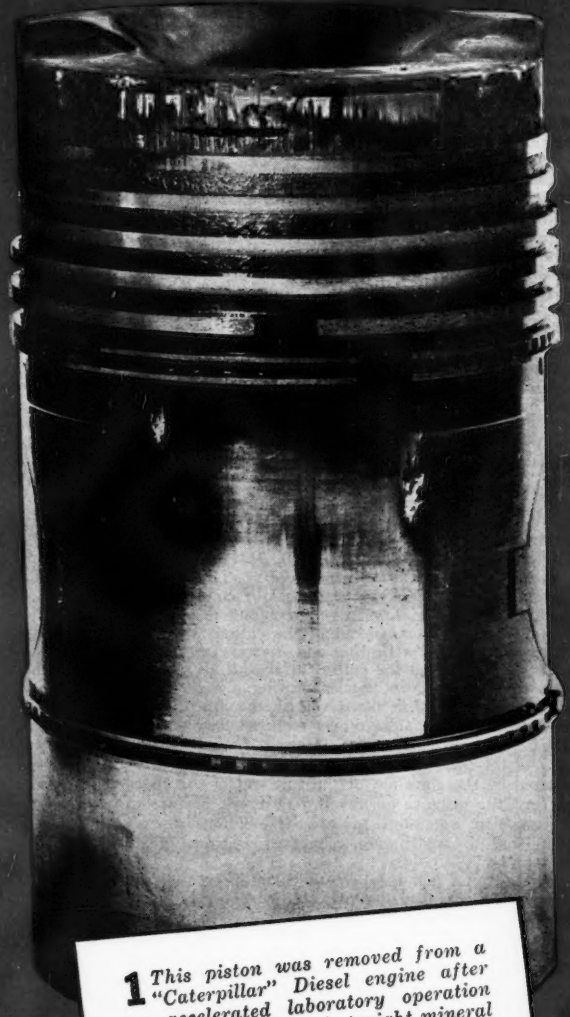
The turning of the furrow slice was found to be accomplished by spiral easement or uniform-pressure curves, similar in principle to those employed in highway and railway engineering. Projections of the path of soil particles were found to be sections of logarithmis or equiangular spirals of the general formula $R = de^{mw}$, where R is the radius, w the angle through which the radius has turned, and a and m constants. The banking or superelevation of this spiral was found to be proportional to the turning, that is $\theta = pe^{kt}$, where p and k are constants and the other symbols have the significance previously explained. *(Continued on page 36)*

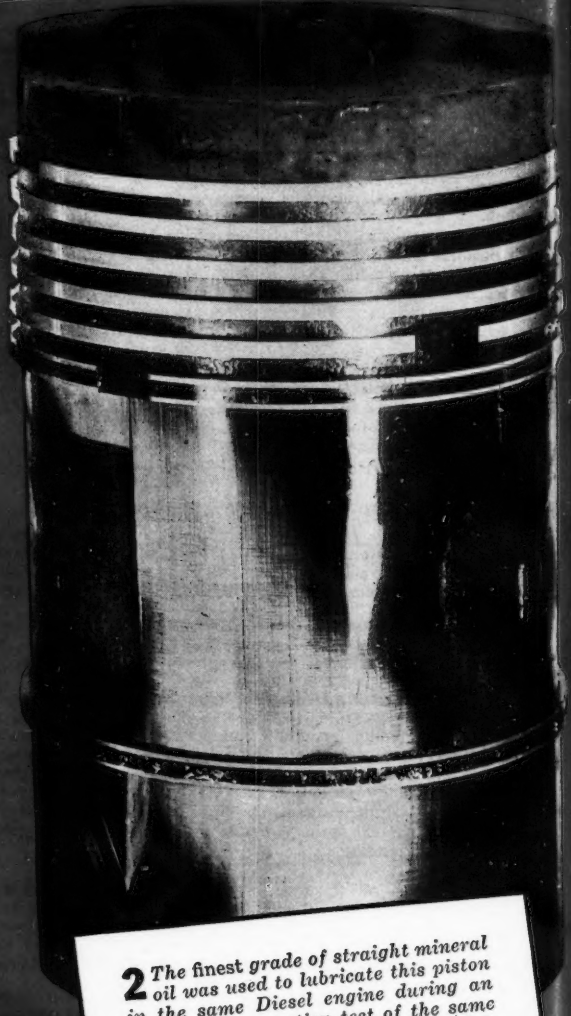
10 TIMES MORE Diesel

Sinclair Ten-ol is a special alloyed lubricating oil developed for "Caterpillar" Diesel engines by Sinclair Refining Company. During the past several months this new Diesel lubricant has been put through exacting research laboratory and field tests.

In full power comparative laboratory tests, "Caterpillar" Diesel engines lubricated with Sinclair Ten-ol gave ten times as many service hours without shut-down as the finest straight mineral oils. In t[aken a] average of all tests, consumption of Ten-ol w[as] approximately one-half that of high grade mine[ral] oils. In one of the tests a Diesel lubricated w[ith] Sinclair Ten-ol operated at extremely high overl[oads] with no damage to the engine and all lubrica[ting] surfaces kept in perfect condition.

Below are authentic photographs of test pist[ons]





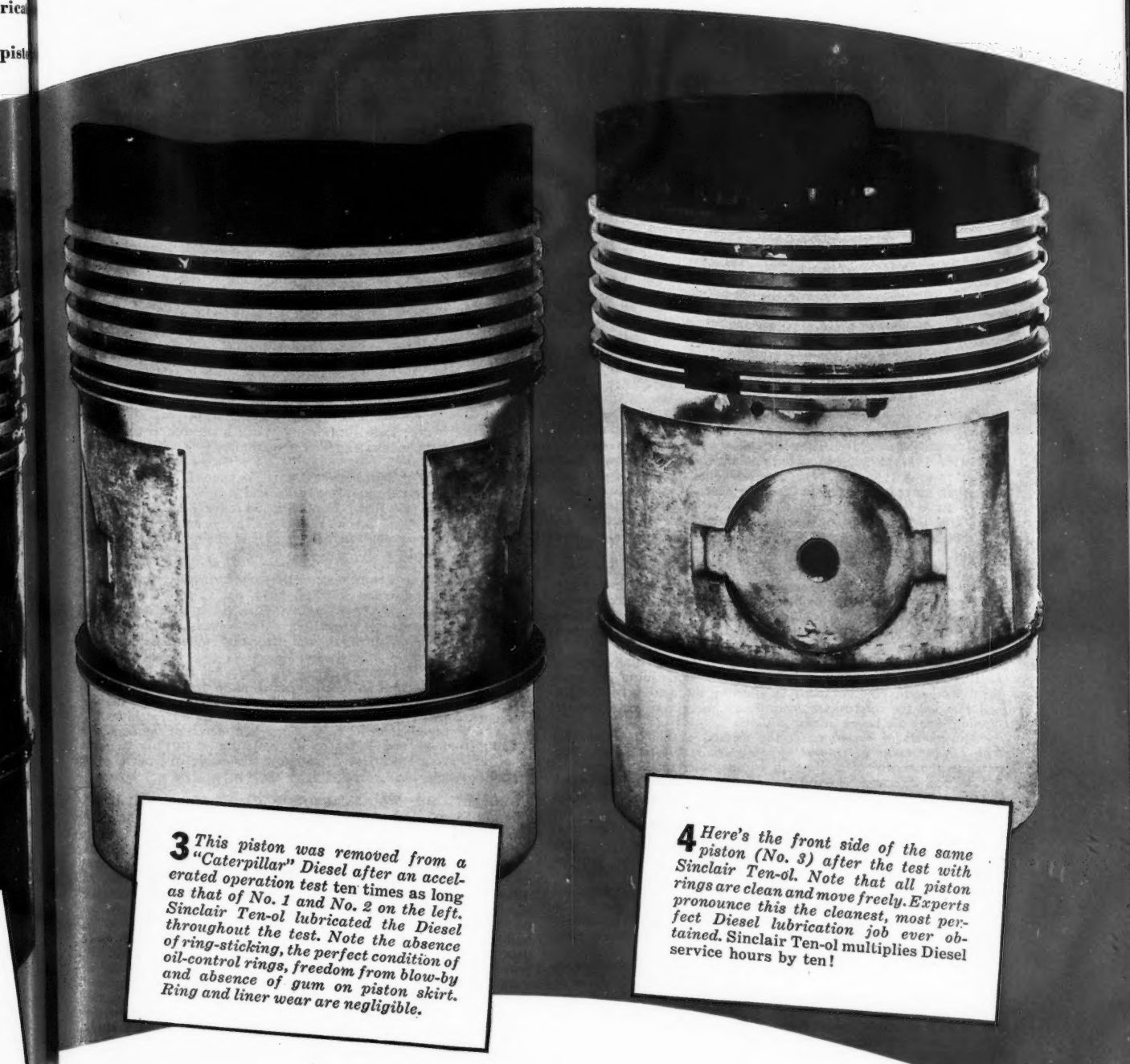
1 *This piston was removed from a "Caterpillar" Diesel engine after an accelerated laboratory operation test. A poor grade of straight mineral oil was used throughout the test. Note the badly stuck rings which caused loss of compression, blow-by and excessive ring wear. Serious oil pumping was also caused by badly plugged oil control rings.*

2 *The finest grade of straight mineral oil was used to lubricate this piston in the same Diesel engine during an accelerated operation test of the same duration as No. 1. Poor piston seal is indicated by signs of excessive blow-by. Note the carbon-coated piston crown, sludge, plugged oil control rings and gum on piston skirt. Wear on liners is still excessive.*

service hours with SINCLAIR TEN-OL

In t aken after exacting laboratory tests. The piston photos have *not* ol w *been retouched.* Read the captions under each photo—they tell the nine remarkable story of Sinclair Ten-ol's outstanding superiority. It d wi will mean a tremendous saving in your own Diesel operation. verlo Sold by your local Sinclair representative. rica

piste



3 *This piston was removed from a "Caterpillar" Diesel after an accelerated operation test ten times as long as that of No. 1 and No. 2 on the left. Sinclair Ten-ol lubricated the Diesel throughout the test. Note the absence of ring-sticking, the perfect condition of oil-control rings, freedom from blow-by and absence of gum on piston skirt. Ring and liner wear are negligible.*

4 *Here's the front side of the same piston (No. 3) after the test with Sinclair Ten-ol. Note that all piston rings are clean and move freely. Experts pronounce this the cleanest, most perfect Diesel lubrication job ever obtained.* Sinclair Ten-ol multiplies Diesel service hours by ten!

Sinclair Ten-ol is recommended as a "New Outstanding Diesel Engine Lubricant" by the Caterpillar Tractor Co. Order Sinclair Ten-ol, Sinclair Diesel fuel and other Sinclair products from your local Sinclair office or write Sinclair Refining Company, 630 Fifth Avenue, New York City.

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Agricultural Engineering Digest

(Continued from page 33)

FIELD CURING OF HAY AS INFLUENCED BY PLANT PHYSIOLOGICAL RESEARCH, *T. N. Jones* and *L. O. Palmer*. Assoc. South. Agr. Workers Proc., 35 (1934), pp. 211-214. Studies conducted by the agricultural engineering division of the Mississippi Experiment Station are briefly reported.

It was found that the practice of windrowing alfalfa hay aids a continuation of the natural physiological process of transpiration, resulting in a greater moisture loss for a day's period. Double windrowing 2 hours after cut furnishes hay with a better color, larger percentage of leaves, and a lower moisture content at the end of the day.

Data indicate that the leaf of alfalfa plants aids greatly in lowering the moisture content of the entire plant. Photomicrographs showed a reopening of the stomata following windrowing 2 hours after cut. The process of crushing large-stemmed hays such as Johnson grass and soybeans will permit a needed change in methods and time required in curing.

IRRIGATION WELLS. New Mexico Sta. Rpt. 1935, pp. 53-58, figs. 4. The progress results are briefly presented of investigations with a number of additional wells.

EFFECTS OF GIN-SAW SPEED AND SEED-ROLL DENSITY ON QUALITY OF COTTON LINT AND OPERATION OF GIN STANDS, *C. A. Bennett* and *F. L. Gerdes*. U. S. Dept. Agr., Tech. Bul. 503 (1936), pp. 40, pls. 3, figs. 18. Studies are reported, the purpose of which was to determine the relative influence of gin-saw speed and seed-roll density on the quality of ginned lint and on the ginning capacity, power requirement, and energy consumption during ginning, and to show the losses in monetary value of the lint that may be associated with tight seed-roll ginning. Brush and air-blast gins were used and were operated at or near the manufacturer's recommended speed, and at speeds 100 rpm above and 100 rpm below this speed. By feeding the cotton to the gin stands at different rates, it was possible to produce both loose and tight seed rolls at each gin-saw speed. The 98 especially selected American upland seed cottons employed in these tests were taken from the crop years of 1930, 1931, 1932, 1933, and 1934. They were grown in 11 states, from Virginia to Texas and Oklahoma. In moisture content they ranged from 6.8 to 20.2 per cent, in staple length from 13/16 to 1 9/32 inches, and widely in other characteristics. The results of tests on lint quality are presented for 46 cottons, and of tests relating to lint turn-out, lint value, ginning time, power required, and energy consumed for from 9 to 57 cottons.

The results showed that there were only small effects on the lint quality and the ginning capacity caused by variations of gin-saw speed 100 rpm above or below the manufacturer's recommended speed. Lowering the speed 100 rpm improved the quality slightly, but raising the gin-saw speed 100 rpm did not change the quality appreciably.

Changes in seed-roll density, caused by changes in the rate of feeding seed cotton to the gin stand, are much more important than changes in gin-saw speed in affecting the quality of the ginned lint and the mechanical operation of the gin stand. Loose-roll ginning gives the better quality cotton.

The effects of variations in the method of ginning employed with a wide range of cottons were materially greater on the preparation component of grade than on any other quality element.

No real effect of gin-saw speed on staple length was found. As the seed-roll density was changed, the staple-length differences between loose and tight-roll samples showed slight tendencies for the loose-roll samples to be classed longer. Laboratory determinations of the upper quartile length and of the variability of fiber length showed little relation of these elements to the gin-saw speed or the seed-roll density.

Grade differences due to variations in gin-saw speed averaged less than one-fifth of a grade improvement for the low speed. The change due to increasing the speed was negligible. Grade differences due to change in seed-roll density amounted to nearly two-thirds of a grade in favor of the loose roll.

Using prices for cotton of like grades and staples prevailing in the Memphis, Tenn., market during the 1932 crop season as a basis of monetary-value computations, the use of a loose seed roll instead of a tight seed roll with a group of cottons averaging 1 3/16 inch in staple length from seed cottons averaging 14.1 per cent in moisture content showed net benefits of approximately $4.50 per bale, or 13 per cent, and almost $1.50 per bale, or 4 per cent, with a group of cottons averaging 1 5/32 inches in staple length from seed cottons having 10.2 per cent moisture content.

The amount of reduction in value as a result of using a tight seed roll for short-staple cottons (about 1 inch) from seed cottons of relatively high moisture content and of substantially lower moisture content averaged 95 and 62 cents per bale, respectively.

Ginning capacity and lint turn-out for the group of seed cottons giving 1 inch staple length and having 9.6 per cent moisture content were generally slightly less with the low saw speed and often were greater with the high speed. Ginning capacity for an outfit of four 70-saw gins was increased 3 bales per 8-hour day by increasing the gin-saw speed 200 rpm and 11 bales by using a tight seed roll instead of a loose seed roll. Lint turn-out showed no definite or consistent relationship to seed-roll density.

Power requirement, though showing some tendency to increase with gin-saw speed, was not materially affected by changing the gin-saw speed 100 rpm above or below the manufacturer's recommended speed. The power requirement was increased 50 per cent, however, by varying the seed-roll density from loose to tight.

Energy consumption per unit weight of seed cotton ginned was not appreciably affected by variations in gin-saw speed or seed-roll density. The interrelationship of ginning time and power requirements caused the difference in energy consumption to be negligible, although indications were that for these small differences the high gin-saw speed and loose seed roll showed slight advantages.

INFLUENCE OF TWO SECONDARY FACTORS IN WEIR MEASUREMENTS. *C. W. Harris*. Wash, Engin. Expt. Sta. Bul. 81 (1935), pp. 14, figs. 3. Studies are reported which demonstrate the need of more careful thought concerning the source of experimental data from which weir coefficients are deduced. First, side-wall extensions are shown to be essential if a coefficient is to remain constant with varying length; second, the cause of departure from the theoretical coefficient as the head decreases is traced to viscous drag. The amount of departure, in the case of a liquid of such low viscosity as water, is found to be proportional to the viscosity.

FARM MECHANICS TEXT AND HANDBOOK, *G. C. Cook, L. L. Scranton,* and *H. F. McColly*. Danville., Ill.: Interstate Printing Co., 1935, pp. 450+[4], figs. (228). This handbook contains sections on woodwork; painting, finishing, and glazing; rope work; belt work and power transmission; harness work; concrete work; sheet metal work; farm forge work; farm home conveniences and sanitation; farm motors; and farm machinery.

STRENGTH TESTS OF STRUCTURAL TIMBERS, I, General principles with data on redwood from gefle and archangel, *C. J. Chaplin* and *J. Latham*. (Gt. Brit.) Dept. Sci. and Indus. Res., Forest Prod. Res. Rec. 2 (1935), pp. (2) + 10. The general principles of these tests are presented and discussed and their practical application demonstrated.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE MONTANA STATION, Montana Sta. Rpt. 1934, pp. 45-48. The progress results are briefly presented of investigations on the storage and use of flood waters for irrigation, water wheels and pumps for irrigation, irrigation methods, and irrigation water supplies.

THE COMBINE HARVESTER, *E. G. Grest*. Sci. Agr., 15 (1934), No. 4, pp. 244-246. In a brief contribution from the Canadian Department of Agriculture, an analysis of data relating to combine harvester costs is presented. The data relate to 63 machines.

It was found that in most cases 700 acres or more for a 15-16-ft combine and 525 acres or more for a 10-12-ft combine must be harvested per year to obtain a reasonable cost per acre of crop harvested.

HITCHES FOR FIELD MACHINERY, *D. E. Wiant* and *L. W. Minium*. South Dakota Sta. Bul. 297 (1935), pp. 55, figs. 33. This bulletin describes, illustrates, and gives technical specifications for hitches to pull two or three implements in the field. It includes information for building hitches to pull any combinations of widths of two or three grain drills, field cultivators, disks, or other similar implements. The information consists of tables of specifications, drawings of designs, and actual photographs of hitches in the field, together with detailed instruction on how to build various hitches. Where the hitches are made up of more than a few parts, drawings of the different designs without dimensions are included. These drawings are to serve as plans or work sheets. The person building the hitch takes the required dimensions from the table of specifications and puts them on the work sheet in the proper place. This gives him a plan, with detailed instructions, for building his particular hitch. After a study of the requirements of a satisfactory hitch, and a study of all available hitches, a series of experimental hitches was built. The hitches described in this bulletin were developed from the experimental hitches and are the results of 2 years' trials and tests in the field and laboratory.

Above: This view shows a portion of the new drafting room at International Harvester Tractor Works, Chicago. The most modern equipment obtainable—including full air conditioning equipment and daylight lighting apparatus—is being used to assure maximum efficiency in this important department.

A New Era of Progress and Prosperity

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The lean time we are leaving behind is already taking its place in the full history of America as only a phase in our development. We shall remember, but we shall be too busy to dwell long upon the past. There have been other such times, and each has had its own real value in building up the sturdy character of millions of men and women — in rekindling the spirit of the pioneer. Agriculture and Industry have closed a splendid year; no one can doubt that far greater things are ahead.

International Harvester is old in years. Its generations of workers have aided in the building of Agriculture since the day of the first McCormick Reaper, 106 years ago. It has prospered as Agriculture has prospered and it has seen each generation of farm families provide itself with a higher and better standard of living. Harvester is ready as always to go along with Agriculture, and to lead the way when it can. In the field of scientific research and modern manufacture this organization is laying its plans along the most progressive lines.

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New fence is "Coated to *stay* — the *electric* way"

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The new Republic Electrical method produces a heavy zinc coating so pure it is silvery in appearance and amazingly tough, pliable, and adhesive — a coating that withstands the most brutal punishment without cracking, flaking, or peeling off. This purer, more uniform zinc coating, applied to copper bearing steel wire of high strength, goes far beyond all previous practice in controlling the destructive effects of corrosion and rust. The new Republic Fence offers you this valuable improvement at no added cost.

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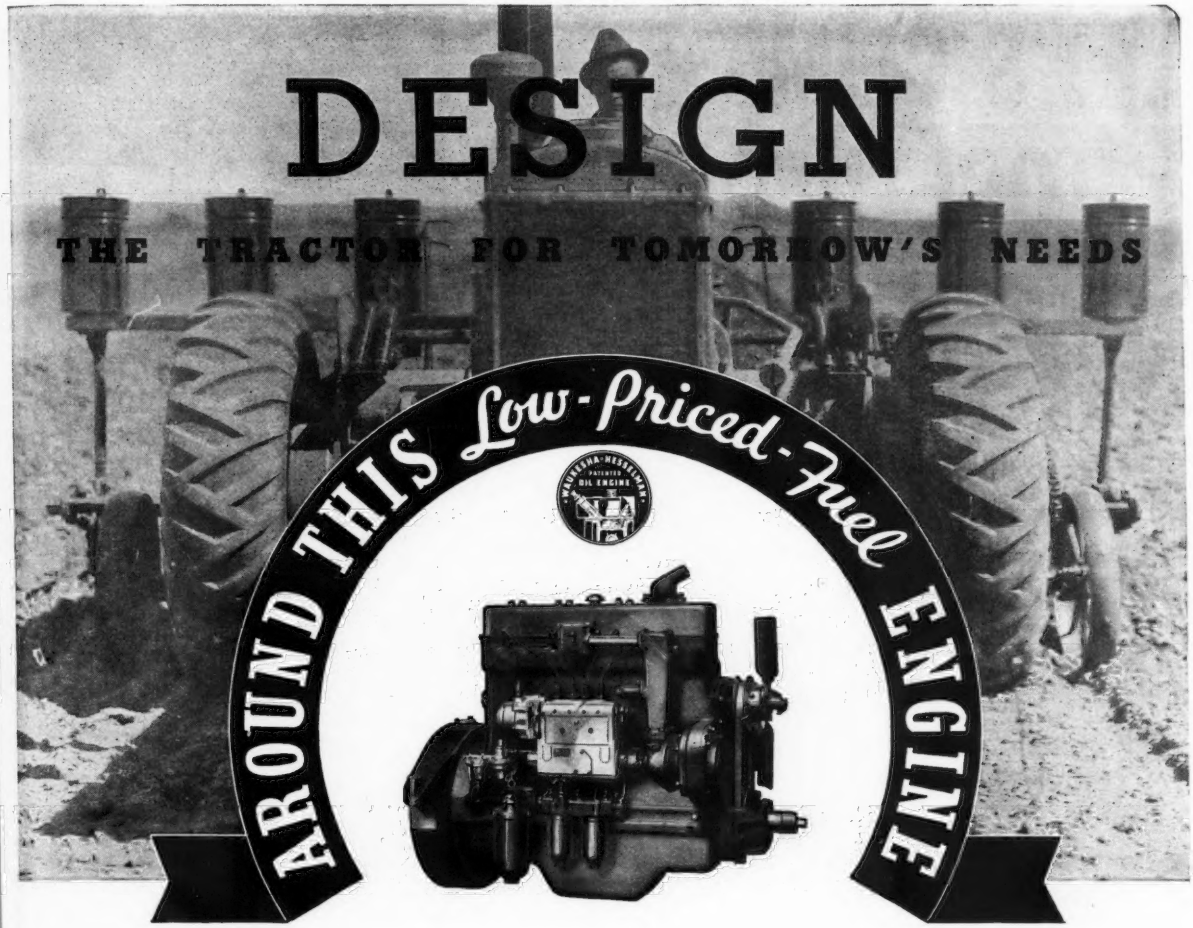

● When the farmer buys a tractor, power comes first. And, since his profits depend on the cost of that power, the farmer has for years been looking for an engine that could really burn low-priced fuel. And you have been wanting to give him such an engine . . . an engine that is itself reasonable in price.

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You'll go farther with Goodyear performance, preference and prestige on your side. You'll make more satisfied customers.

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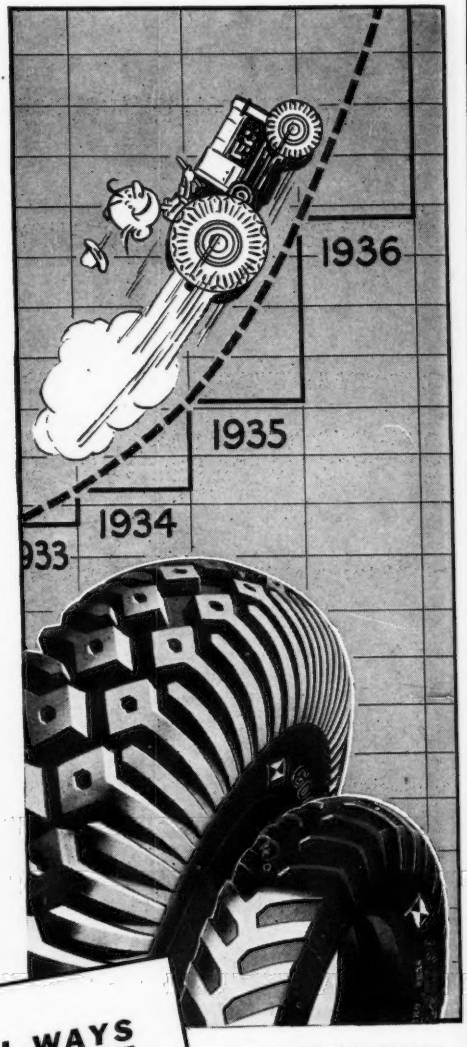

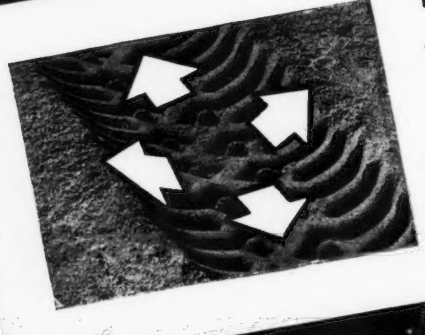

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The GOODYEAR All-Traction Tractor Tire is the only tractor tire that provides traction in all directions —forward, backward or on hillsides. Sure-footed traction in mud, in sand, on the highway.

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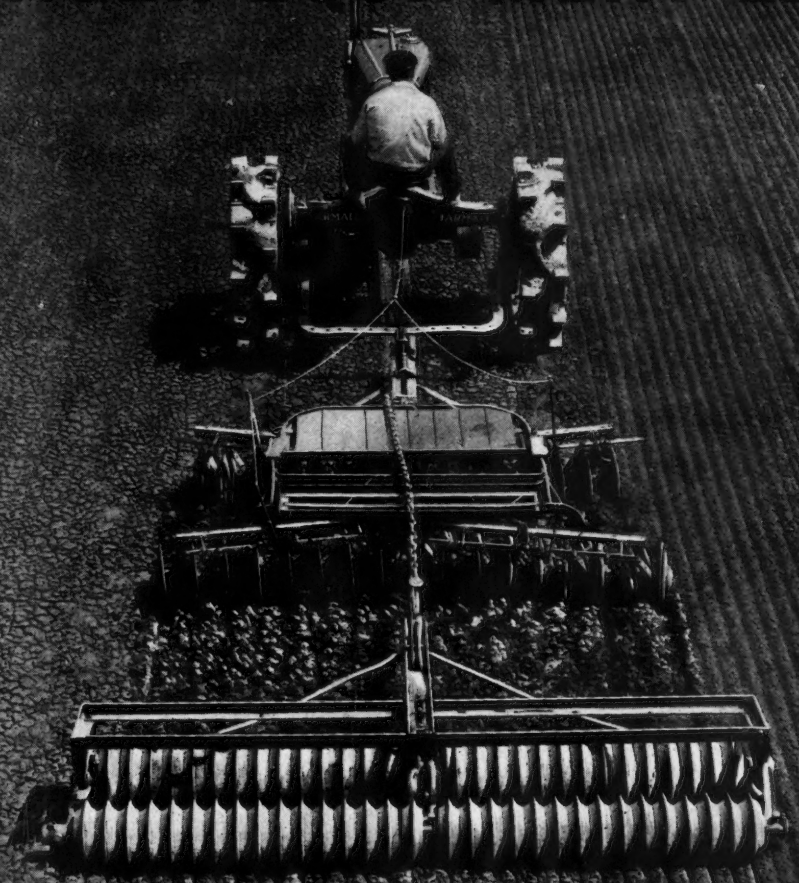

● The place where metals really show their mettle is in modern farming operations. For the mechanical beast and his burdens travel at speeds which tremendously increase stresses, wear, shock and abrasion. The simpler metals of a slower era cannot be expected to survive this terrific punishment. It takes metals of super-strength and super-toughness.

The constantly increasing use of the Nickel Alloy Steels and Nickel Cast Irons in farm machinery testifies to their ability to meet these specifications. Leading equipment manufacturers find that the slightly higher initial cost of employing these alloys for vital parts returns the investment a hundred-fold in increased dependability and longer equipment life.

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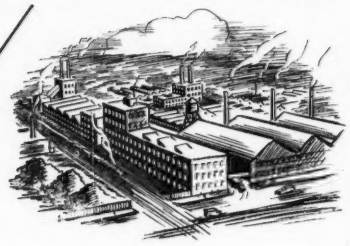
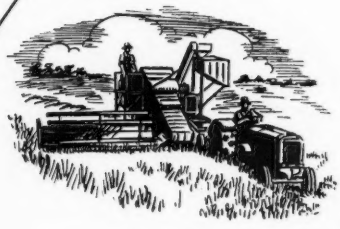
each working independently and each serving its own localized community, has grown a vital industry that probably has exercised a greater influence on the economic and social welfare of mankind than has any other human endeavor. It is the FARM EQUIPMENT INDUSTRY.



When these pioneer smithies, a century ago, undertook to build machines which would increase the productive capacity of the agricultural worker, they set in motion the process of farm mechanization which freed millions of people from the stern necessity of producing their own food and clothing material and made it possible for them to engage in new occupations, create new industries and develop the arts, sciences and professions.



It was these emancipated farm workers who furnished the muscle and brawn—and the brains, as well—to develop America into the industrial giant she is among the nations of the world.

In the early years of the industry, most of the builders of farm machines were merely artisans, skilled only in the use of shop tools. Few were trained in the science of mechanics and none in the science of applying mechanics to agriculture.

Then came the day of modern engineering! Colleges and Universities started training men in the sciences of both mechanical and agricultural engineering. These men found places in the industry and it was their training that was largely responsible for the recent developments in the industry.

Of course, we are proud of the industry's past, but we get more comfort and enjoyment out of contemplating its future. There are opportunities ahead. There are new jobs to be done by machines. There are old ones to be done in a better and more economical way. Its future lies mainly with young men now in the classrooms, who soon will take their places in the industry and lead on to bigger and better things.

THE FARM EQUIPMENT INSTITUTE

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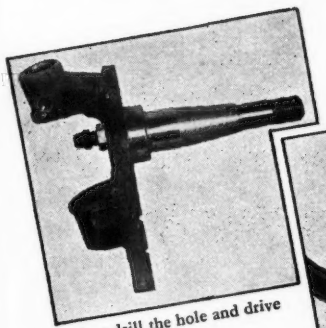
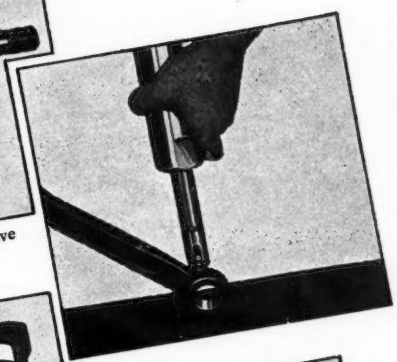
NEW ALEMITE DRIVE FITTING

...MAKES ITS OWN THREADS!...

No More Tapping!

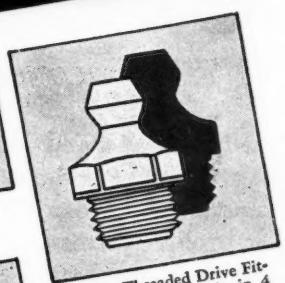
Will Save Thousands of Dollars for Manufacturers!



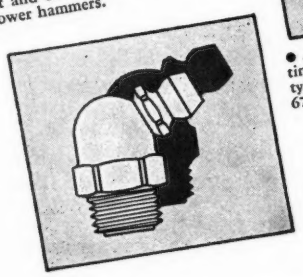


• Just drill the hole and drive the fitting in.

• Straight and elbow drive tools for use with power hammers.



• Alemite Threaded Drive Fittings are now available in 4 types—straight, and with 30°, 67°, or 90° elbow.



HERE is a brand new Alemite Hydraulic Fitting which makes its own thread when driven into a ⅜" hole. The time and cost of tapping operations are entirely *eliminated*. Yet these new Alemite Threaded Drive Fittings are offered at no increase in price over standard Alemite Fittings.

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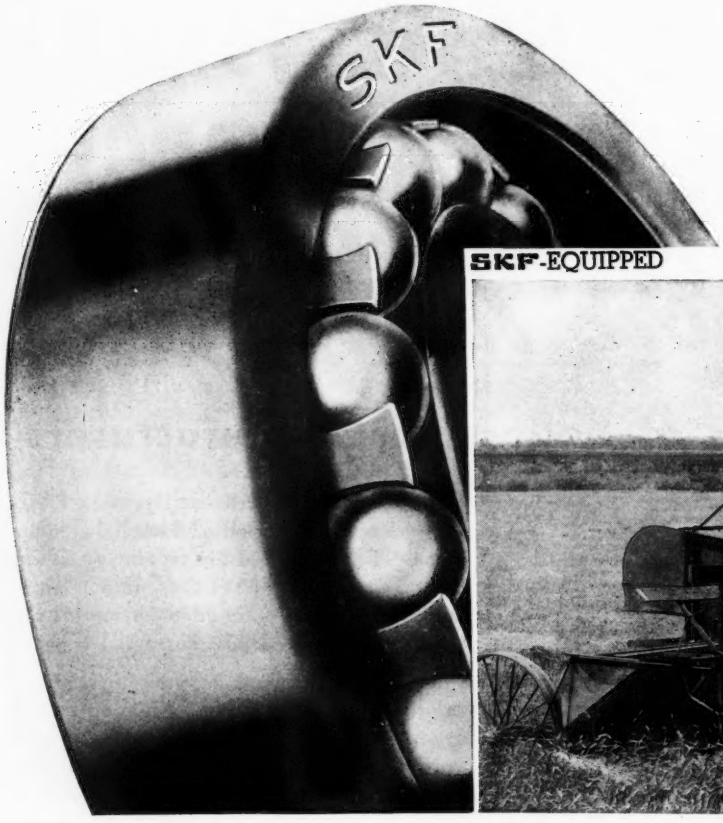
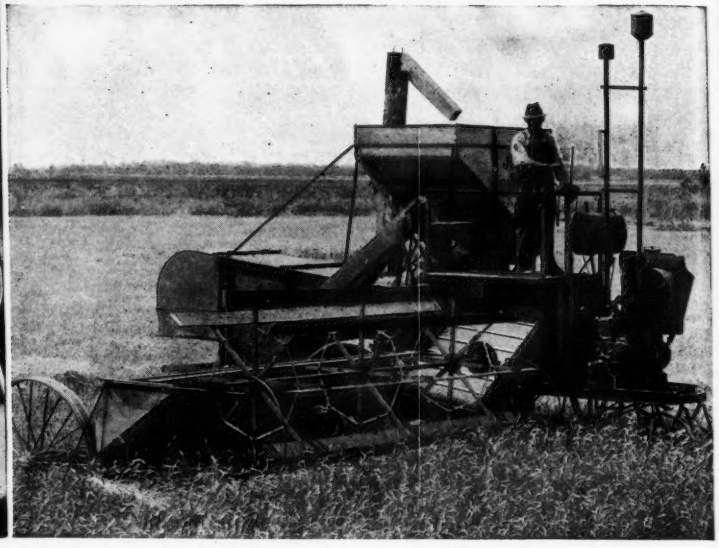
WORLD'S LARGEST MANUFACTURERS OF LUBRICATING PRODUCTS



SKF-EQUIPPED BUILT BY DEERE & COMPANY

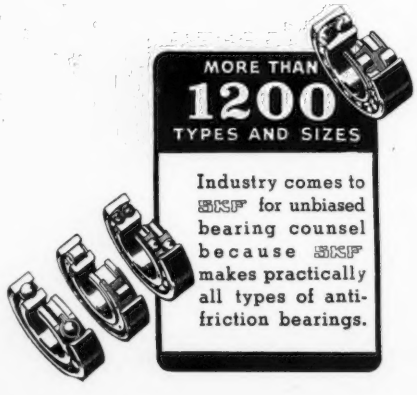


DEERE & CO. — SKF

names that mean QUALITY in agricultural equipment

● The effectiveness and economy of SKF Bearings reflect the high quality standards that Deere & Company have maintained for 100 years. That's why Deere & Company use SKF to protect harvester cylinder shafts against misalignment, lost motion, heating and vibration caused by wear.

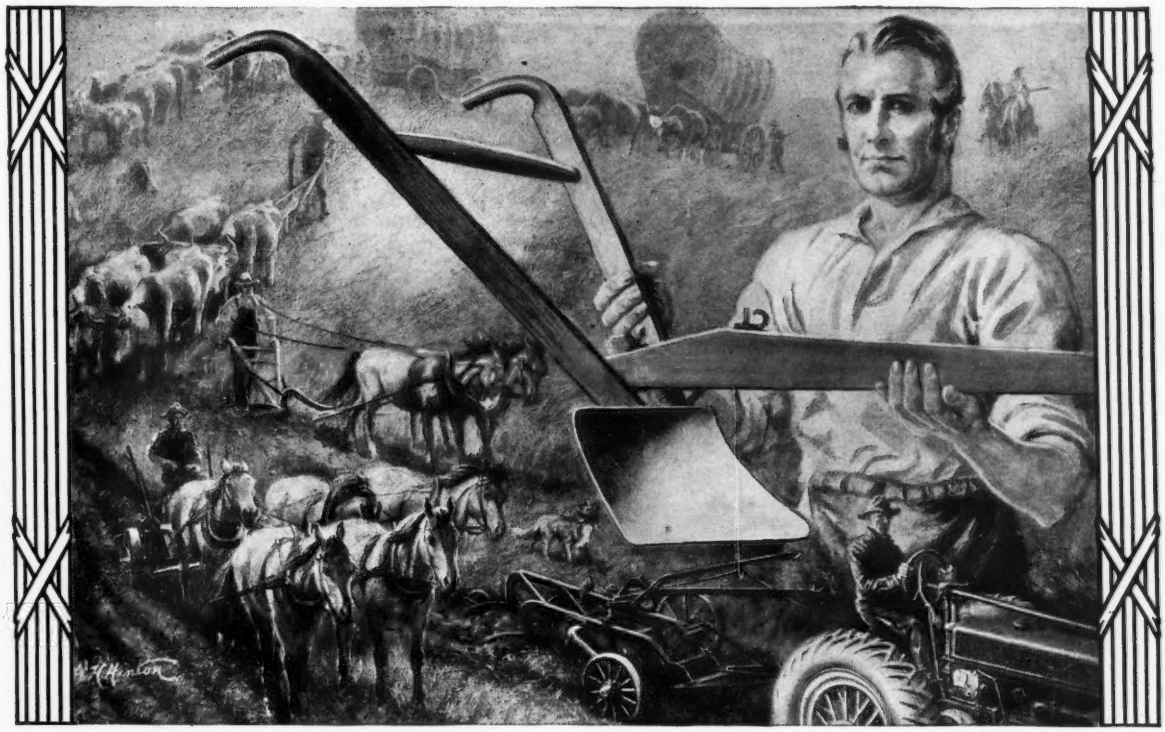
SKF Bearings are ideally adapted to many applications on modern design combines. Double-row, self aligning, they fit standard shafting, and require no machining. Year by year, step by step, they have kept pace in achievement with the agricultural industry. Therefore, SKF congratulates Deere & Company upon the completion of its century of progress. 3758


MORE THAN
1200
TYPES AND SIZES
Industry comes to SKF for unbiased bearing counsel because SKF makes practically all types of anti-friction bearings.

SKF INDUSTRIES, INC., FRONT ST. & ERIE AVE., PHILA., PA.

SKF

BALL AND ROLLER BEARINGS



One Hundred Years Ago

John Deere Gave to the World the Steel Plow

THE year was 1837. The place, Grand Detour, Illinois. John Deere, the village blacksmith, had been challenged . . . His friend, Lewis Crandall, had threatened to "go back East if you can't build me a plow that'll scour."

John Deere was worried, for well he knew that Lewis Crandall's problem was the problem of the bustling West. He had heard the talk of sturdy pioneers up and down the wagon trails. "It's the richest soil that lies outdoors," they said. "But no plow'll ever turn it, once the sod is broken."

No need to tinker with the cast-iron and wood plows brought from the East, concluded Deere. Only a plow with a highly-polished surface could scour its way through this sticky soil.

. . . A highly-polished surface, mused the blacksmith.

Fortunate, indeed, that the sun shone brightly the morning John Deere went to the community's sawmill to repair a broken shaft. Its brilliant rays bounced from the polished surface of a broken saw blade into the alert eyes of John Deere. Wait . . . that's it . . . steel . . . steel for plows . . . no soil could stick to that smooth surface.

Day and night he worked, perfecting his great idea . . . building the plow of his dreams. Into the field he took it . . . back to his shop for changes . . . out again and back again, until he knew it was right.

A memorable day it was when, surrounded by skeptics and well-wishers, John Deere turned a clean furrow with his new steel plow. He had conquered the prairie soil . . . he had given new hope to the pioneers of the West . . . he had made possible the permanent settling of a great agricultural empire.

Now, Lewis Crandall could stay and farm his rich acres.

* * * * *

Little did John Deere realize that his name was to be burned deep into the history of agricultural progress. Humble, yet proud of his workmanship . . . practical, yet with vision enough to sense the needs of the times, he built plows that set the standard of plow quality the world over.

"I'll never put my name on an implement that hasn't in it the best that is in me," John Deere once said. That was his ruling pride, the ideal which has guided the organization that bears his name today.

Eleven great factories, building equipment for every farming operation . . . branch houses in every principal farming area . . . thousands of dealers selling and servicing John Deere goods—these are the living, thriving monuments to the man who gave to the world the steel plow, one hundred years ago.

FLAME-SEALED
AGAINST RUST

"Metals, particularly in thinly deposited layers, seldom are completely impervious in a chemical and microscopic sense . . . ordinary nickel plating applied directly on steel is sufficiently pervious to admit moisture and gases which cause rusting. While zinc coatings are not so susceptible to this condition, they are however no exception." — J. L. Schueler, Agr. Eng. Vol. 14, No. 12.

Flame-Sealing, developed and used exclusively by Continental, combats this inherent defect of deposited coatings by fusing cracks, pores, and voids; driving out occluded gases; producing a single homogenous armor in which opportunity for electrolytic destruction of the zinc is reduced to a minimum. Flame-Sealing also makes the zinc coating dense and tough, proof against flaking or fracture despite severe bending. By sealing out rust it adds years to fence life without adding to fence cost; makes fencing a more permanent asset for permanent programs of soil conservation and profitable land utilization.

CONTINENTAL STEEL CORP., U. S. A.
General Offices: KOKOMO, INDIANA
PLANTS at CANTON, KOKOMO, and INDIANAPOLIS

"Permanent Farm Improvements" is a new booklet with foreword by R. U. Blasingame. Samples or quantities for distribution supplied on request.

CONTINENTAL Flame-Sealed FENCE

CONTINENTAL
83 STEEL PRODUCTS FOR FARM AND HOME

The Development of a Low Cost Hay Dryer

(Continued from page 27)

varieties of hay, such as Mammoth Yellow soybean, proved difficult in that the drying was slow and drawn out over a long time.

3 Present indications are that drying is just as rapid with intermittent blowing as with continuous blowing. Further observations are needed to find the extent to which this is true, in order that the most efficient operation of the system can be definitely determined.

4 Indications with this plan of drying are that a barn with a hay mow of 20 to 40-ton capacity can be equipped for drying the season's hay crop with an investment of about $300.

5 Most of the tests conducted to date dealt with hay of above the average grass and weed content. Weather conditions were at times adverse, though a period of three or four days of rain and high humidity is yet to be encountered during the critical drying period of 8 to 10 tons of hay. Further observations are believed necessary before this system can be declared entirely successful.

FIELD CURING, 1936

The field curing system consisted of a distributor box, having seven pipe outlets with a control valve in each outlet; seven lateral pipes, made up of 28-in sections of 6-in, slip-joint conductor pipe; and caps for closing off laterals where desired. A ¼-in slot, 28 in long, was made in each section of the pipe, over which hay was piled. A 12-in blower was attached to the distributor box and was driven by a 6-hp gasoline engine at 1600 rpm.

For the first trial three of the pipes, with slotted opening on top, were covered with partially cured alfalfa hay in three ricks 4 ft wide, varying in height from 3 to 6 ft, and in length from 20 to 30 ft. It was found that the hay packed too tightly over the slotted opening to allow sufficient passage of air. A period of high humidity was encountered during this trial, and since no method of heating the air had been provided, the hay dried out very slowly with considerable spoilage.

For the second trial of the field curing system, the 6-hp engine was replaced with a 3-hp air-cooled engine, and a housing was built around engine and blower so that all air taken into the blower would pass over and around the engine. Two ricks of alfalfa hay were built with two pipes under each. The openings in these pipes were turned away from each other so that air was blown out in a horizontal plane. With this arrangement hay did not close off the opening and a good distribution of air was evident, as determined by use of smoke.

Further studies of this system are needed to determine proper proportions of ricks and a handier method of covering hay in case of rain. Observations show that when tarpaulins were used to protect the hay from dew or rain, it was found that they must be supported or kept from direct contact with the ridge of each rick, or sweating and bleaching would result. By using a smoke smudge at the blower intake, it was found that more air was passing through the sides than through the top portions of the ricks and that apparently the ricks should not exceed 30 ft in length. By utilizing the heat given off by the engine to preheat the air entering the blower, it was found that the temperature of the air delivered to the hay was increased from 9 to 18 deg above outside air temperature, and the relative humidity decreased 12 to 20 per cent below outside relative humidity.

"One day," reports Reuben Lehnus, Bonfield, Illinois, "I shelled 3710 bushels of corn, made 3 sets and moved 3½ miles—and my Diesel RD4 used a scant 11 gallons of 7c Diesel fuel." • No wonder Diesel RD4 owners are making money doing farm power contracting work—no wonder this 4-5 plow model is the fastest selling Diesel tractor ever built! • At the rate reported by owners the country over, the Diesel RD4 should save nearly twice its purchase price—on fuel cost alone—*doing its first 10,000 hours of work!*

CATERPILLAR
REG. U. S. PAT. OFF.
TRACTOR CO., Peoria, Illinois

WORLD'S LARGEST MANUFACTURER OF DIESEL ENGINES AND TRACK-TYPE TRACTORS

A Martin MESSAGE to AGRICULTURAL ENGINEERS

GENTLEMEN:

This year, by all indications, marks the beginning of the most important period in the nation-wide movement for the prevention and control of Soil Erosion in America.

It will definitely place a renewed emphasis on *the individual farmer's responsibility* in saving the soil, the nation's basic source of wealth. No Engineer that attended the sessions of the Soil and Water Conservation Division at the annual meeting of the ASAE at Estes Park, and the Winter Meeting of the Society in Chicago, could have missed the conclusion that the success of all this movement revolves around the individual farmer — that although engineering counsel and direction are a necessary help, *the construction and maintenance* of Terraces and Ditches for instance, are the farmer's own job.

If we understand it, the prime purpose of this whole movement is to awaken the individual farmer to *his own most vital interests* — which of course are the concern of every citizen, whether it is realized or not.

This is certainly implied in the proposition authoritatively set forth at Estes Park, for an ultimate survey of the engineering needs of every farm in the country. It is certainly implied in the reports of the sub-committees on Terracing Equipment and Construction, and Terrace Planning, at the Winter Meeting.

★ ★

The Government Demonstrational Projects have performed a tremendous service. They have made farmers of America conscious of the need for Terracing, Ditching, and other control measures, as never before.

Now — backed by the practicable intelligent engineering counsel available to every owner and tiller of the soil — *the job is up to the farmer!*

It is his job, as plowing is his job. No doubt the intelligent farmer will do his plowing *better* because of engineering counsel — but the work will be his own. And so with all other work of farm operation. It will continue to be the farmer's own as long as America is America.

The farmer will do his Terracing and maintenance work as he does his plowing — when soil and weather conditions and his own time permit. No more than for his plowing and cultivation will he await his turn to use a large outfit that may not be available when he desires it.

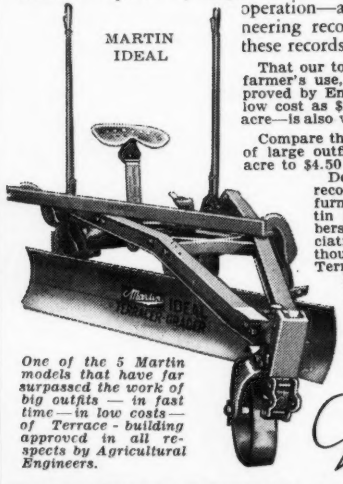
Obviously the farmer cannot afford a large outfit for Terracing costing up to $5,000, any more than he can afford such equipment for plowing or cultivation. For Terracing and Ditching he requires specialized tools costing no more than ordinary farm implements.

★ ★

This is what we supply — what we have supplied to the farmers of America and many foreign countries, for the last 20 years.

That our Terracing and Ditching tools — drawn by farm tractors, or teams — match the finest work of the big outfits in specifications required by Engineers — in time — in all points of operation—are matters of official engineering records. Your inspection of these records is invited.

MARTIN IDEAL



That our tools made for the individual farmer's use, are building Terraces approved by Engineers in all points, at as low cost as $4.96 per mile—45 cents per acre—is also written in engineers' records.

Compare these Martin costs with those of large outfits running from $1.50 per acre to $4.50 per acre, and up to $75.00

Details of these and other records of the Martin will be furnished on request. The Martin is employed in large numbers on Government and Association work as well as on many thousands of farms, not only for Terracing, but for all kinds of Ditching, Irrigation Work, Rice Levee Building, Digging and Cleaning Ponds.

Engineers, County Agents and Soil Conservation officers are invited to write for records and descriptive literature.

One of the 5 Martin models that have far surpassed the work of big outfits — in fast time — in low costs — of Terrace - building approved in all respects by Agricultural Engineers.

M. Steele
Pres. & Gen. Mgr.

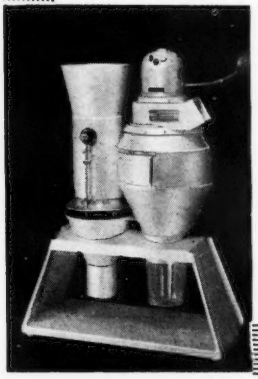
OWENSBORO DITCHER & GRADER CO., INC.
Dept. 30 Owensboro, Kentucky

A valuable addition to the equipment of any grain laboratory!

BATES LABORATORY ASPIRATOR

Designed by E. N. Bates, in charge Pacific Coast Grain and Rice Investigations, USDA

A device designed to separate any granular material by means of passing it through a controlled air current. For use with wheat, rice, barley, clover, vetch, etc. Used by Bureau of Plant Industry, USDA; U. S. Field Station; Universities of Idaho and Montana; Pennsylvania State College; Products Protection Corp., etc.



LIST PRICES:

Heavy Galvanized Metal $105

Solid Brass Throughout $130

Bulletin and discounts on application

Free sample testing service

Ricetown Sample Devices Co.

Manufacturers of Rice Grading and Testing Equipment of High Precision

STUTTGART, ARKANSAS

Ultraviolet Ray Makes Eggs Tell Age

EGGS can be made to tell the truth about their age by exposing them to ultraviolet light, it has been discovered at the University of Utrecht.

The trick depends on the phenomenon known as fluorescence. Ultraviolet radiation is itself invisible to the human eye, but it causes various substances to shine with light of different colors, or to fluoresce.

To the human eye an egg is just an egg. But under a beam of ultraviolet a really fresh-laid egg glows with a very pronounced red coloration. Less freshly laid eggs shade into blue, and the older they are the deeper the blue.—*Science Digest.*

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS WANTED

ARCHITECT, with college training and experience in England desires employment where his training and experience will apply. Prepared plans and supervised erection of large housing scheme in England. Following World War service in which he served with rank of captain, he became superintendent of construction of three of the largest hotels in Canada. Five year's experience as assistant architect, Central Experimental Farm, Department of Agriculture of Canada. Made intensive study of mechanical and nonmechanical ventilation of barns and other farm buildings. Can furnish best of references. Will go anywhere. Married. PW-274